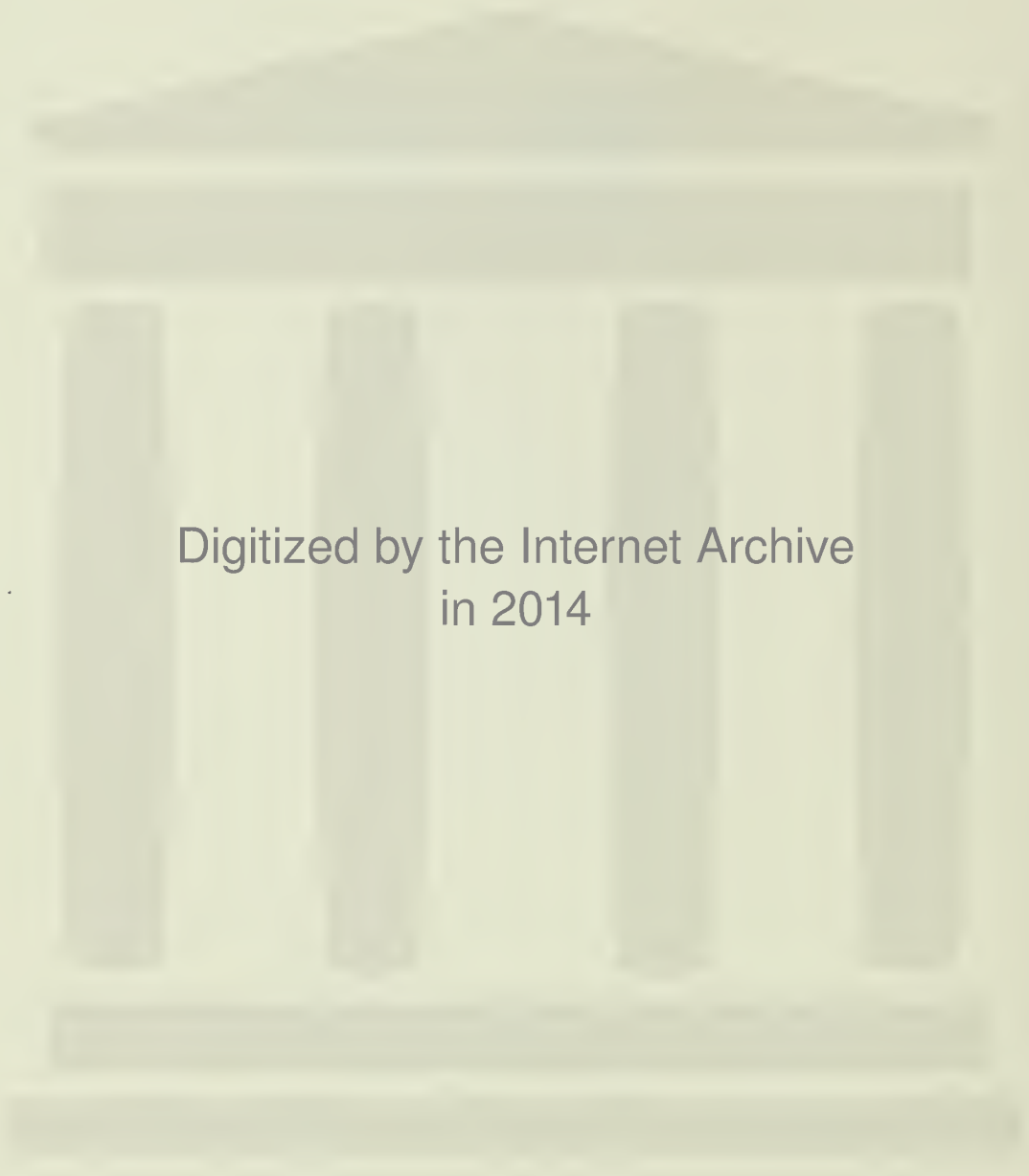

A PREDESIGN REPORT ON

MARINE WASTE DISPOSAL

VOLUME III SUPPLEMENTARY
ECOLOGICAL INVESTIGATIONS -1971

CITY AND COUNTY OF SAN FRANCISCO

BROWN AND CALDWELL
CONSULTING ENGINEERS
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APRIL
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F 236F

April 23, 1973

Mr. S. M. Tatarian, Director
Department of Public Works
City and County of San Francisco
260 City Hall
San Francisco, California 94102

PREDESIGN REPORT ON MARINE WASTE DISPOSAL

In accordance with our agreement for engineering services dated June 23, 1969, and amended December 23, 1970, we submit herewith the final report on the supplementary ecological investigations. This report includes the results of the studies on the distribution of Dungeness crab zoea and adults in the Gulf of the Farallones and the studies on the toxicity of wastewater effluents to various life stages of local crab species.

The results of the plankton studies indicate a low population of Dungeness crab zoea in the Gulf of the Farallones. Catches of adult crabs were also low with considerable fluctuation. Laboratory bioassay tests performed on adults, juveniles, larvae, and eggs of several species of crabs showed no statistically significant effect due to wastewater effluents. We conclude, therefore that the results of the 1971 study reinforce the conclusions with respect to ecological design criteria presented in Volume I of the predesign report on marine waste disposal.

BROWN AND CALDWELL

Frank J. Kersnar

Frank J. Kersnar

CONTENTS

CONTENTS

CHAPTER 1

INTRODUCTION

In June 1969 the City and County of San Francisco authorized an engineering and ecological study of marine disposal of treated wastewater. This study was undertaken by Brown and Caldwell and was completed in 1971 with the publication of a two-volume report entitled "A Predesign Report on Marine Waste Disposal". The basic finding was that discharge of primary effluent, properly diluted, would not adversely affect the marine environment of San Francisco Bay or the Gulf of the Farallones. The text and findings of the report was contained in Volume I, and detailed field and laboratory data were presented in Volume II.

The objectives of the ecological phase of the 1969-70 marine waste disposal study were twofold: (1) to provide baseline data on the marine environment in waters adjacent to the City of San Francisco; and (2) to predict the ecological effects of discharging large quantities of treated municipal wastewater through submarine outfalls. Accordingly, several marine habitats were investigated, including pelagic, benthic, and intertidal. Field surveys were conducted to determine the distribution and diversity of the marine flora and fauna. Laboratory studies included toxicity and biostimulatory experiments to assess the response of selected species to wastewater exposure.

The Dungeness crab, Cancer magister, was given special emphasis in the 1969-70 study because of its commercial importance. But in spite of the combined efforts of the California Department of Fish and Game and Brown and Caldwell, the distribution of the crab zoea (larvae) in the Gulf of the Farallones was not defined. Also, several aspects of the laboratory bioassay studies warranted further study, particularly regarding the incidence of terminal prezoea stages. For these reasons, a supplemental study on crabs was recommended by both Brown and Caldwell and the Technical Advisory Board of the City of San Francisco.

Authorization and Scope of Supplemental Work

In November 1970, the City and County of San Francisco authorized this supplemental study concerning the Dungeness crab. Specific phases of the work to be undertaken were as follows:

1. Establish a limited study area within an offshore zone encompassing the best sites for ocean outfall discharges as developed by the physical oceanographic and engineering studies.

2. Study the distribution of Dungeness crab zoea in this area by means of plankton tows during the winter months of 1971 and continue the enumera-

tion and general identification of all zooplankton collected in these tows to provide additional background data.

3. Study the distribution of adult crabs in this area by a trapping program.

4. Reinstitute and continue for a period of six months the laboratory bioassay program on the response of adult crabs, eggs, and zoea to effluent from the San Francisco treatment plants.

5. Present the results of the supplementary investigations as Volume III of the Predesign Report on Marine Waste Disposal.

Acknowledgements

During the conduct of the studies reported in this volume we received the continuing support and assistance of many of the same people who contributed to the success of studies reported in Volume I. In addition, we would like to thank Mr. Frank Damato, Mr. Joe Damato, Mr. Vito Pomilia and Mr. Dominique Bagalia of the Crab Boat Owner's Association who provided us with valuable information regarding the San Francisco crab fishery. We would also like to thank Mr. Pete Smith and Mr. Charles Elliot of the Alaskan Department of Fish and Wildlife who aided the laboratory program by making it possible for us to obtain egg-bearing Dungeness crabs from Kodiak Island, Alaska. Finally, we would like to thank the staff of the Marine Resources Laboratory of the California Department of Fish and Game, Menlo Park, for their assistance in reviewing this manuscript.

CHAPTER 2

FIELD INVESTIGATIONS

Field investigations were undertaken to augment previous data on the distribution of Dungeness crabs in the vicinity of the proposed ocean outfall sites. Since few crab zoea were collected during the 1969-70 studies, zooplankton tows were continued through the 1971 hatching crab season. Crab zoea and other zooplankton were identified and enumerated. These data were supplemented by a trapping program with the objective of measuring the adult crab population in the area. Qualitative data on the crab fishery was obtained by interviewing local crab fishermen and representatives of the California Department of Fish and Game. Through these efforts a better assessment of the study area as a nursery ground for Dungeness crabs could be made.

Study Area

Based upon the information available in late 1970 on best sites for marine disposal, an area adjacent to the coast from Point Lobos to Lake Merced was selected for study. Six sampling stations (Fig. 2-1) were chosen within approximately a 25 square mile area. All but one of these (Station 5) were located at fixed navigational buoys. These stations are described as follows:

Station	Location	Depth at MLLW, ft
1	Bell buoy R "4"	38
2	Channel buoy No. 8	45
3	Channel buoy No. 2	50
4	Gong buoy R "2M"	45
5	One-half distance between stations	
	4 and 6	36
6	Bell buoy R "2"	32

The study area is strongly affected by tidal currents entering and leaving San Francisco Bay (see Chapter 4, Vol. I). During the winter months, net movement at the surface is strongly seaward. However, United States Geological Survey studies (1971) showed the net movement at the bottom is towards San Francisco Bay throughout the year. Because of these currents, plankton samples do not necessarily reflect the populations at a particular station. Rather, these samples should be viewed as being representative of the entire Gulf of the Farallones region.

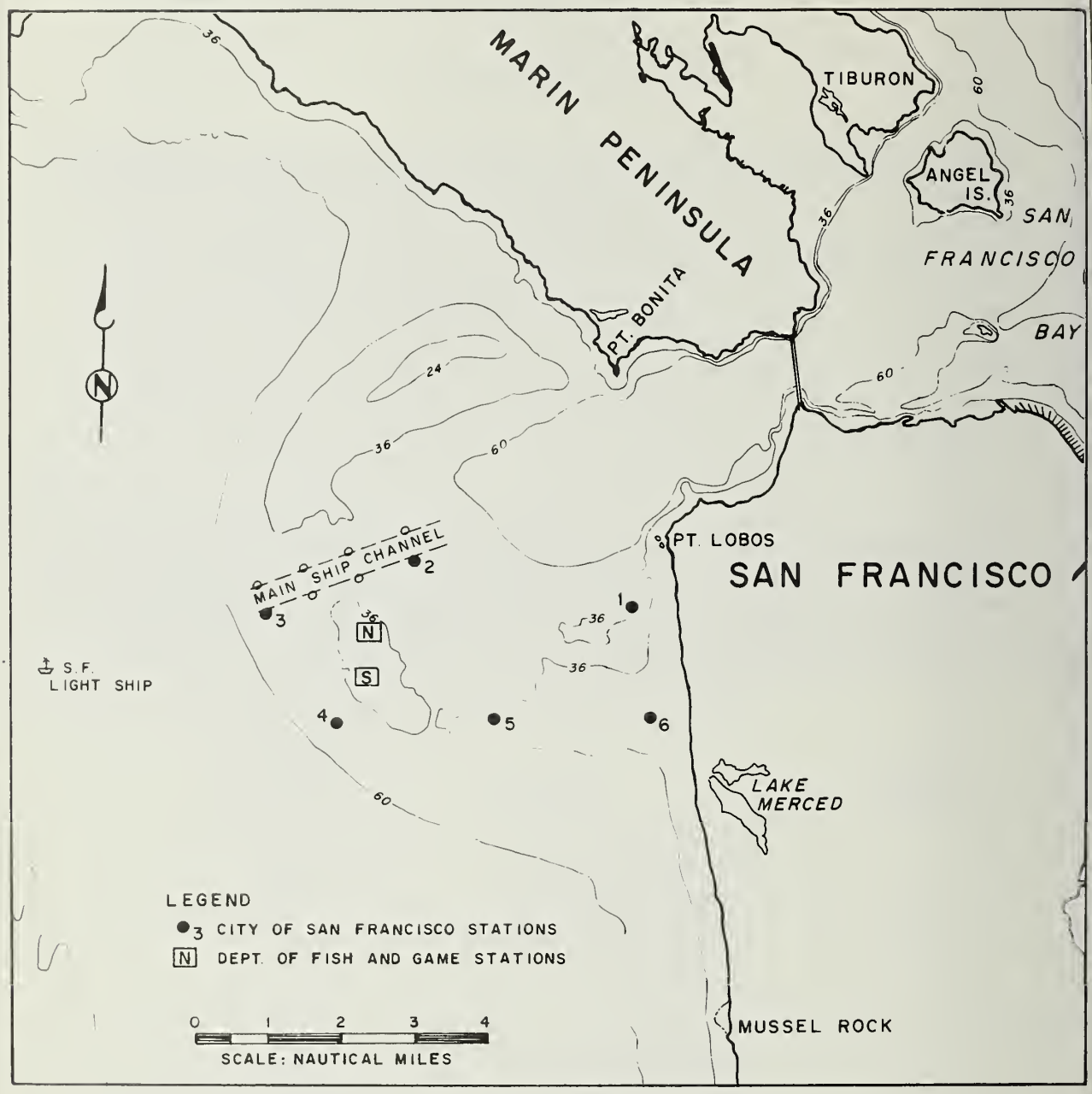


Fig. 2-1. Location of Sampling Stations

Sampling Period

The sampling period was chosen to correspond to the known egg hatching and larval development period of Dungeness crabs in the Gulf of the Farallones. As originally planned, sampling was to be on a biweekly basis from December 1970 to April 1971. However, adverse weather conditions delayed the start of the sampling period until January 21, 1971. In total, plankton tows were made on six dates from January 21 to April 14, 1971, and an additional ten cruises concerned only with crab trapping were made through April 22, 1971.

Sample Collection and Examination Procedures

Plankton collections were obtained from 5-minute tows of a Clarke-Bumpus sampler with a No. 10 mesh net. Tows were made at one and eight meter depths. Samples from these tows were preserved for subsequent identification and enumeration of the zooplankton in the laboratory. Because of the difficulties encountered with the taxonomy of these organisms, no attempt was made to identify zooplankton further than order although various life stages were differentiated within each order. An exception was made with crab zoea; these were identified to genus and species, if possible. Samples from all the collections were retained by Brown and Caldwell should additional analyses be necessary in the future.

The collections of adult crabs were made using standard 48-inch commercial crab pots. On all but the April 1 cruise, the female escape hatches were wired shut so that all crabs larger than four inches, spine-to-spine, would be retained (some smaller crabs were caught clinging to the wire webbing of the traps). Each trap was baited with approximately three pounds of fish scraps. The traps were then dropped at each sampling station for a minimum of 24 hours, although weather conditions often delayed retrieval for several days. After recovery the crabs were identified to species and the number caught per trap was recorded. Because of the different exposure times, no attempt was made to determine the capture rate.

Results of Plankton Sampling and Examinations

The number of plankton net tows at each station during each cruise is presented in Table 2-1. In total, 39 tows at a depth of one meter and 35 tows at 8 meters were made. Results of plankton analyses are presented in Appendix A.

The average zooplankton concentration in the 74 samples analyzed was 3100 per cu m and the range was from zero to 20,300 per cu m. These concentration ranges were similar to those found in the 1969-70 studies. Large aliquots, averaging about one-third of the total volume of each sample, were specially examined for crab zoea. In this work, 929 crab zoea were found of which 80 were identified as genus Cancer, but only two were identified as Cancer magister. Both of these were collected from one meter deep at station 2, one on February 3, and the other on April 14. Identification of the remaining 78 Cancer zoea to species was not possible because of the inadequacy of published descriptions. Thus, the concentration of Cancer magister zoea may have been much higher than indicated by the plankton analyses.

Table 2-1. Number of Plankton Tows at Each Sampling Station

Date	Station number and depth											
	1		2		3		4		5		6	
	1 meter	8 meter	1 meter	8 meter	1 meter	8 meter	1 meter	8 meter	1 meter	8 meter	1 meter	8 meter
January 21	2	-	-	-	-	-	-	-	-	-	1	1
February 3	2	2	2	2	2	-	-	-	-	-	-	-
February 8	1	1	1	1	-	1	1	1	2	1	1	1
March 1	1	1	1	1	1	1	1	1	1	1	1	1
March 29	2	2	1	1	-	-	-	-	1	1	2	2
April 14	2	2	2	2	2	2	2	2	2	2	2	2
Total	10	8	7	7	5	4	4	4	6	5	7	7

A summary of the crab zoea collection data is presented in Table 2-2. Crab zoea were found in 58 of the 74 samples and the average concentration was 19 per cu m. An average of 11 and 28 zoea per cu m were found at the one and eight meter depths, respectively. The reasons for the greater abundance of crab zoea in the deeper waters were not determined.

The data do not reveal any consistent distribution pattern with respect to sampling station. However, more crab zoea were collected from the south stations situated on or at the outside edge of the bar than those inside the bar or adjacent to the ship channel. Collections from stations 4, 5 and 6 accounted for over 61 percent of the total. Slightly higher concentrations of crab zoea were found on March 29 and April 14 from the eight meter tows as shown in Fig. 2-2. High densities of 116 zoea per cu m at station 5 and 250 zoea per cu m at station 6 were recorded for these dates, respectively.

Results of Trapping Program. During the four months of 1971, five crab sampling cruises were completed which resulted in the collection of crabs from 21 trappings. Table 2-3 presents the collection dates and number of crabs collected from each sample station. The nearshore stations (1, 2 and 6) were sampled most frequently, while the most distant stations (4 and 5) were sampled the least. Rough seas frequently prevented the research vessel from getting to station 4, which is at the outer edge of the bar. At station 5, the infrequent sampling resulted from the fact that this station is not marked directly by a navigational buoy, and it was difficult to return to the exact location of the trap drop. Several crab traps at this station were lost.

Table 2-3 also shows the number of male and female Cancer crabs for each species and Table 2-4 shows the average number of crabs collected per trap. Of the 86 Cancer crabs collected, 64 were Cancer magister; 59 of these were males. The other species collected, C. productus and C. antennarius, were mostly females. Only three of the 23 female Cancer crabs collected were egg-bearing. One of these was C. magister and the remaining two were C. productus.

Over 60 percent of the crabs collected were from the south bar stations (4, 5 and 6), although most of the sampling effort was at stations 1, 2 and 3. Almost

Table 2-2. Crab Zoea Collection Data

Cruise number	Date, 1971	Station	Depth of flow, meters	Sample No.	Calculated No. of zoea per cubic meter		
					Total	Cancer spp	Cancer magister
1	21 January	1	1	303	0	0	0
		1	1	289	0	0	0
		6	1	299	78	3	0
		6	8	302	21	1	0
2	3 February	1	1	301	1	0	0
		1	1	273	7	2	0
		1	8	271	6	0	0
		1	8	275	3	1	0
		2	1	270	3	1	0
		2	1	277	4	3	1
		2	8	278	27	0	0
		2	8	274	68	0	0
		3	1	272	6	3	0
		3	1	306	2	0	0
3	8 February	1	1	244	0	0	0
		1	8	269	38	3	0
		2	1	247	9	5	0
		2	8	242	34	0	0
		3	8	249	39	0	0
		4	1	241	1	0	0
		4	8	240	14	2	0
		5	1	267	2	0	0
		5	1	202	0	0	0
		5	8	201	36	2	0
		6	1	203	1	1	0
		6	8	243	3	0	0
4	1 March	1	1	207	86	11	0
		1	8	206	34	0	0
		2	1	204	0	0	0
		2	8	210	0	0	0
		3	1	213	0	0	0
		3	8	211	4	0	0
		4	1	209	0	0	0
		4	8	214	6	0	0
		5	1	205	0	0	0
		5	8	212	9	0	0
		6	1	208	0	0	0
		6	8	305	25	7	0
5	29 March	1	1	235	0	0	0
		1	1	229	0	0	0
		1	8	237	51	0	0
		1	8	239	53	3	0
		2	1	228	0	0	0
		2	8	236	6	0	0
		5	1	230	116	56	0
		5	8	233	27	0	0
		6	1	234	0	0	0
		6	1	232	0	0	0
		6	8	238	32	16	0
		6	8	231	56	9	0

Continued next page....

Table 2-2. Crab Zoea Collection Data, Continued

Cruise number	Date, 1971	Station	Depth of flow, meters	Sample No.	Calculated No. of zoea per cubic meter		
					Total	Cancer spp	Cancer magister
6	14 April	1	1	225	6	0	0
		1	1	221	5	0	0
		1	8	223	5	0	0
		1	8	215	3	0	0
		2	1	255	21	15	3
		2	1	258	11	7	0
		2	8	250	19	19	0
		2	8	254	1	1	0
		3	1	248	9	9	0
		3	1		4	4	0
		3	8	245	4	0	0
		3	8	256	6	0	0
		4	1	252	7	0	0
		4	1	253	12	0	0
		4	8	251	5	0	0
		4	8	257	4	0	0
		5	1	224	3	0	0
		5	1	226	13	0	0
		5	8	218	2	0	0
		5	8	222	19	19	0
		6	1	220	17	0	0
		6	1	216	0	0	0
		6	8	227	69	1	0
		6	8	217	250	3	0

half of the total crabs were collected on two trappings, at stations 5 and 4 on February 20 and April 22, respectively. Thus, there was a trend indicating higher crab densities towards the south side of the bar. This trend was also indicated in the crab zoea data.

Department of Fish and Game Crab Sampling. In the 1971-1972 season the California Department of Fish and Game surveyed the adult crab population in the Gulf of the Farallones in cooperation with the local crab fishermen. The record of commercial crab landings and the analysis of selected crab trappings by Fish and Game personnel aboard the fishing boats formed the basis for this survey.

Three commercial trappings were analyzed by the Department of Fish and Game from two localities on the bar. These localities were designated as DFG-N (Department of Fish and Game-North) and DFG-S (Department of Fish and Game-South) as shown in Fig. 2-1. Both were sampled December 16, 1971, and DFG-S was also sampled January 10, 1972. No sampling of adult crabs had been conducted by Fish and Game during the spring of 1971.

The collection procedures used by the commercial crab fishermen were similar to those used by Brown and Caldwell in 1971. The principal differences were the method of baiting and the number of days fished. The commercial traps were baited with frozen squid enclosed in plastic containers that prevented the bait supply from being eaten by the captured crabs. Thus, crabs would continue to be attracted to the bait for three to five days. In addition, the large number of commercial pots set by the fishermen provided a larger sample size than the Brown and Caldwell collections. Only Cancer magister crab were studied during these cruises.

Table 2-3. Adult Crab Collections, January Through April, 1971

Cruise number	Trap retrieval date	Station number	Species collected					
			Cancer magister		Cancer productus		Cancer antennarius	
			male	female	male	female	male	female
1	January 21, 1971	1	-	-	-	1[a]	-	1
		2	3	1[a]	1	-	-	-
		3	1	-	-	-	-	1
2	February 19	1	1	-	-	-	1	2
	February 20	1	7	1	-	-	-	-
		2	7	1	-	-	-	-
		5	2	-	-	-	1	10
		6	8	-	-	-	-	-
	February 21	6	5	-	-	-	-	-
		6	5	1	-	-	-	-
3	March 5	1[b]	-	-	-	-	-	-
		2	2	-	-	-	-	-
		3	-	-	-	-	-	-
		4	-	1	-	1[a]	-	-
		6[b]	-	-	-	-	-	-
4	April 1	1[b]	-	-	-	-	-	-
		5	-	-	1	2	-	-
		6	-	-	-	-	-	-
5	April 22	2	2	-	-	-	-	-
		3	1	-	-	-	-	-
		4	15	-	-	-	-	-
	Totals		59	5	2	4	2	14
			64		6		16	

[a]Egg-bearing females.

[b]Bait gone - crab pot malfunction or vandalism.

Table 2-4. Average Number of Crabs Collected Per Trap on Each Cruise

Sampling date	Cancer magister		Cancer productus		Cancer antennarius		All species, average number per trap
	Male, average number per trap	Female, average number per trap	Male, average number per trap	Female, average number per trap	Male, average number per trap	Female, average number per trap	
January 21	1.3	0.3[a]	0	0.7[a]	0	0.7	3
February 19, 20, 21[b]	5	0.4	0	0	0.3	1.7	8.1
March 5	0.7	0.3	0	0.3[a]	0	0	1.3
April 1	0	0	0.3	0.7	0	0	1
April 22	6	0	0	0	0	0	6

[a]These collections include egg-bearing females.

[b]These three dates were averaged as one cruise.

The results of the three commercial cruises studied by DFG are presented in Table 2-5. During the December and January sampling period, 86 traps were set resulting in the collecting of 393 Dungeness crabs. Only 11 (about 2.8 percent) were females; all were egg-bearing or had recently spawned. The average number of crabs per trap ranged from 7.2 at DFG-S in December to 3.3 at DFG-S in January. The average of the total collections from the DFG-N and DFG-S localities was approximately 4.5 crabs per trap.

Table 2-5. Dungeness Crab Collection Data From Department of Fish and Game

Date	Station	Number of traps	Days fished	Dungeness crabs collected			Legal size catch per trap, lb
				Male	Female	Total	
12-16-71	DFG-S	19	5	132	6	138	4.7
12-16-71	DFG-N	41	5	169	1	170	4.7
1-10-72	DFG-S	26	3	81	4	85	1.7

During the three commercial cruises, the legal size catch per trap was also determined. The results indicated a very poor January collection of 1.7 lb per trap. This is equivalent to approximately one legal size crab per trap. Both collection periods were considered poor by the local crab fishermen.

Comparison of Trapping Results. The average number of Dungeness crabs per trap from both the 1971 winter samplings and the Department of Fish and Game 1971-72 study are presented by station in Fig. 2-3. While there were differences among sample size and collection periods between the two studies, very similar results were obtained in regard to the average number of crabs per station and the ratios of males to females in the collections. The average trap yields from the DFG stations were very similar to the average yields from the 1971 stations which received the largest sampling. These stations (1, 2 and 6) and two DFG stations averaged approximately four Dungeness crabs per trap retrieved. Variations between the average yields of the three other 1971 stations may have been the result of the small sample size.

Both collections produced very small numbers of females during the sampling periods. Patrick Collier, of the Menlo Park Office of the Department of Fish and Game, indicated that this low percentage of females was to be expected as recent observations had indicated that the females do not feed during the egg-bearing and hatching period of the winter and spring months. It was unlikely, then, that the few female crabs obtained during either crab sampling study was an accurate reflection of the female crab population in the study area.

The large variation in trap yields from month to month at a single station, which was observed in the 1971 program (Table 2-4) had also been found in Fish and Game collections from many different localities. These fluctuations may have been the result of a large-scale movement of adult crabs between the collection dates. DFG tagging studies have demonstrated that adult crabs are capable of moving over a large distance in a relatively short period of time.

Interviews With Crab Fishermen. During the 2-year marine disposal study, we have interviewed local commercial crab fishermen to obtain additional information on Dungeness crab population distributions. These interviews have provided valuable information about the past and present fishery as well as practical knowledge about the life history of the Dungeness crab. The following statements reflect the shared opinions of four veteran crab fishermen: Frank Damato, Joe Damato, Vito Pomilia and Dominique Bagalia.

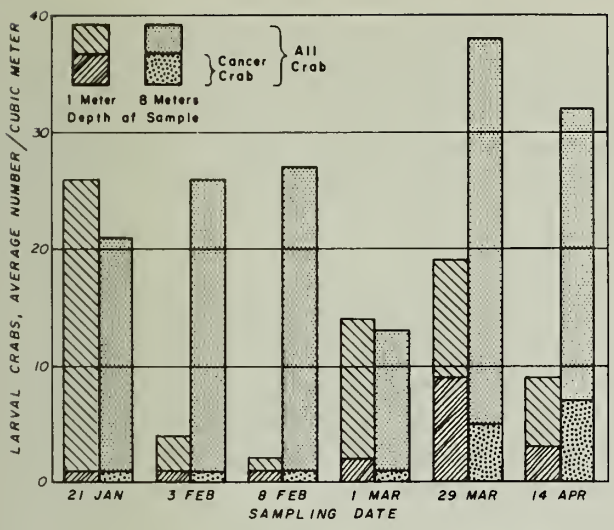


Fig. 2-2. Average Density of Larval Crabs at Each Sampling

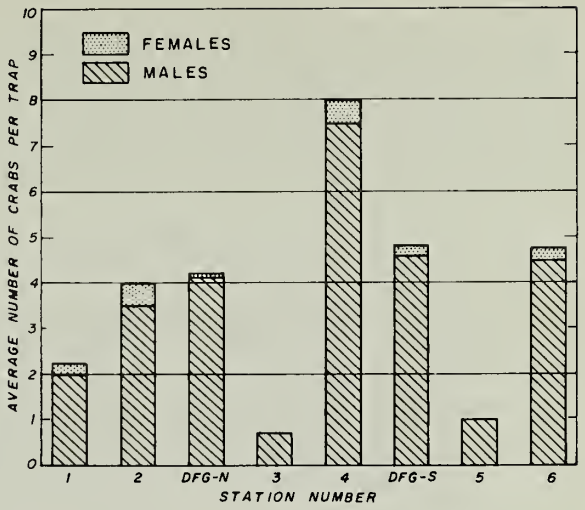


Fig. 2-3. Average Number of Dungeness Crabs Collected Per Trap at Each Sampling Station

1. The San Francisco crab fishery has declined almost steadily since 1957.

2. The most productive areas for commercial crab collection have moved farther and farther offshore over the past ten years. (Note: the California Department of Fish and Game, Menlo Park, in their review of this report did not support this contention). Normal trapping technique used to be to string pot lines at increasing distances from shore until the crabs were found. Present technique is to go offshore (20-50 fathoms) and work back towards shore in the event crabs are not found.

3. The 1971-72 crab catch was the worst on record. Fewer than a dozen boats were operating by mid-season.

4. Opinion is divided over the effect of drag boats on the crab catches. Some fishermen think that the draggers destroy a large number of soft-shell crabs, while other fishermen feel that the effect of the drag boats is minor.

5. The study area off Ocean Beach used to be a major fishing ground. Since 1965, however, this area has played only a minor role in the total crab landings of San Francisco.

Conclusions From the Field Investigations

The plankton sampling program conducted throughout the Gulf of the Farallones during the winter and spring of 1969-70 and reported on in Volume I resulted in

the identification of only three Dungeness crab larvae from a total of 85 sample tows. The more intensive sampling program of the small study area in 1971 resulted in the identification of two Dungeness crab larvae from a total of 74 sampling tows. This number was less than one percent of all the crab larvae found in the samples. We believe that the following conclusions can be drawn from the plankton investigations

1. The 1971 results support the 1969-70 data.

2. The results from both years reflect the greatly reduced population of Dungeness crabs in the Gulf of the Farallones.

3. The concentration of Dungeness crab larvae in the 1971 study area does not differ substantially from that found during the 1969-70 study in other areas of the Gulf of the Farallones.

With respect to the crab sampling, the most abundant adult Cancer crab in the study area during 1971 and 1972 was the Dungeness crab. Adult males comprised the bulk of the catch. However, based on DFG's observation that female crabs do not feed during the winter and spring egg-bearing period, the paucity of females collected does not necessarily mean that they were absent from the study area.

Fluctuations in crab yields may have been the result of movement of adult crabs throughout the Gulf of the Farallones. Tagging results from the California Department of Fish and Game have indicated that adult crabs are capable of moving over large distances in a relatively short period of time although most recoveries have been in the area of release. Thus, crabs found in the vicinity of a future municipal outfall in the study area would not necessarily be exposed to the diluted effluent field for long periods of time.

The results of the interviews with professional crab fishermen indicated that the study area presently contributes only a small portion to the San Francisco commercial landings. Historically, the area was an active fishing ground, and if the crab population increases, the area may again produce successful harvests. The possible role that this area could play in the future fishery makes it important to protect all life stages of the Dungeness crab.

CHAPTER 3

LABORATORY INVESTIGATIONS

The laboratory phase of the 1971 Cancer magister bioassay study was a continuation of the studies begun in 1970 and reported in Volume I. At the conclusion of the previous work, it was recognized by both the Technical Advisory Board and Brown and Caldwell that additional studies were still needed. Therefore, a supplemental six-month bioassay study was undertaken to further define the effects of San Francisco wastewater effluents on Dungeness crabs.

Bioassays were performed on composite samples of wastewater effluents during the 1970 program using a variety of vertebrate and invertebrate species. Particular attention was directed toward the commercially important Dungeness crab (Cancer magister). This species is known to have undergone a serious decline in population as evidenced by reduced commercial catches in recent years. In the supplemental work in 1971, bioassays were performed using various life stages of the Dungeness crab including eggs, larvae, and juveniles. Other crab species, such as adult hermit crabs (Pagurus samuelis), larval and adult shore crabs (Petrolisthes cinctipes) and larval kelp crabs (Pugettia producta) were tested when Dungeness crab eggs were not available.

In addition to possible acute toxicity, other effects of the wastewater on Dungeness crabs were also investigated. One of these was the production and survival of prezoea, which is a stage in the life cycle of the Dungeness crab occurring immediately after egg-hatching. As will be discussed later in the report, the occurrence of prezoea as a viable life stage is subject to controversy. But the results of the 1970 program suggested that further work was needed in this area because of the incidence of prezoea during the experiments. Another area of concern was the possible long-term effects of continuous exposure of crab larvae (zoea) to wastewater effluents. Therefore, this aspect was studied in several experiments.

PROCEDURES

The 1971 bioassay program was conducted at the Bodega Marine Laboratory of the University of California. Space was made available to the researchers under a rental agreement, and the personnel of the Bodega Marine Laboratory were not involved in the conduct or the direction of the work. The laboratory was equipped with a flowing seawater system which provided dilution water typical of the seawater found along the California coast. This permitted comparison with the 1970 bioassay work which used dilution water typical of the outflow from San Francisco Bay.

Test Apparatus

The experiments conducted during the 1971 program employed both static and continuous-flow bioassay systems.

Static Bioassay Apparatus. The static bioassay apparatus differed from that described in Vol. I, Chapter 5. Ten zoea were placed in each of a series of 250 ml glass bowls containing various dilutions of wastewater effluent. The zoea were then incubated in a cold room at approximately 12 C. About 75 percent of the effluent dilution was changed daily. This procedure was used in early experiments before the continuous- flow apparatus was operable and was an effort to approximate continuous- flow conditions by manual control. Thus, these experiments were not true static bioassays as performed in 1970.

Continuous- Flow Bioassay Apparatus. The continuous-flow apparatus was based on the design of a serial diluting system developed jointly by the University of California Sanitary Engineering Research Laboratory and the California Department of Fish and Game. The original design was modified so that electrically operated solenoid valves controlled the delivery of effluent samples and dilution water to the test aquaria. This change increased the versatility in programming dilutions.

A photograph and a schematic diagram of the continuous flow apparatus are shown in Figs. 3-1 and 3-2, respectively. During operation, water entering from the laboratory seawater system (A in Fig. 3-2) was filtered and then decanted from container to container until the seawater apportioning battery (B) was filled. The size of each container was selected to obtain the desired final dilutions. When all the containers were full, the seawater was allowed to overflow to a drain (C).

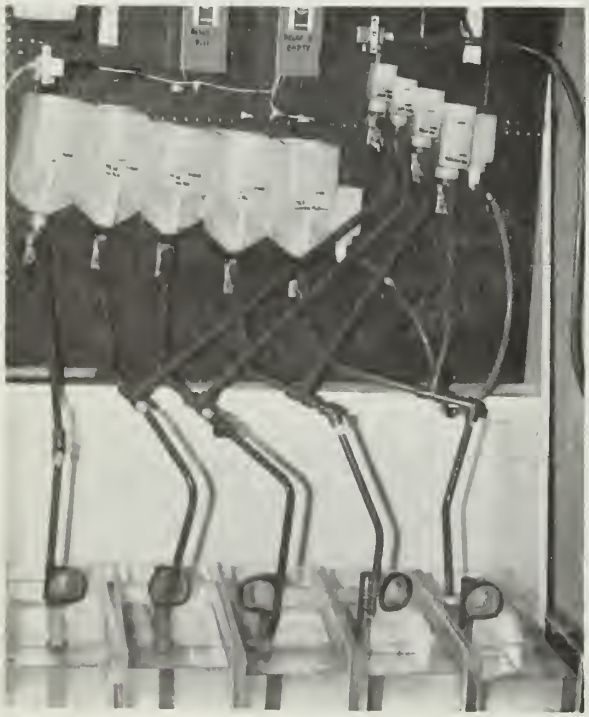


Fig. 3-1. Continuous Flow Serial Dilution Battery With 30 Liter Aquaria

The wastewater sample entered the apparatus from a storage tank (D) by means of a Sigma motor pump (E). The effluent sample then filled the effluent apportionment apparatus (F) in a manner similar to that described for the seawater battery.

At a preset time interval the solenoid dump valves (G) on both the wastewater and seawater containers allowed the contents to empty. The water mixed and then entered the 30-liter test aquaria. A master timer controlled the displacement rate in the aquaria, and this was set at approximately four hours. The standard dilutions (wastewater to seawater) used in the experiments were 1:400, 1:200, 1:100, 1:50, 1:20, and a seawater control. Dilutions of less than 1:20 were not used because the salinity would be lowered to such an extent that the test organisms might be affected.

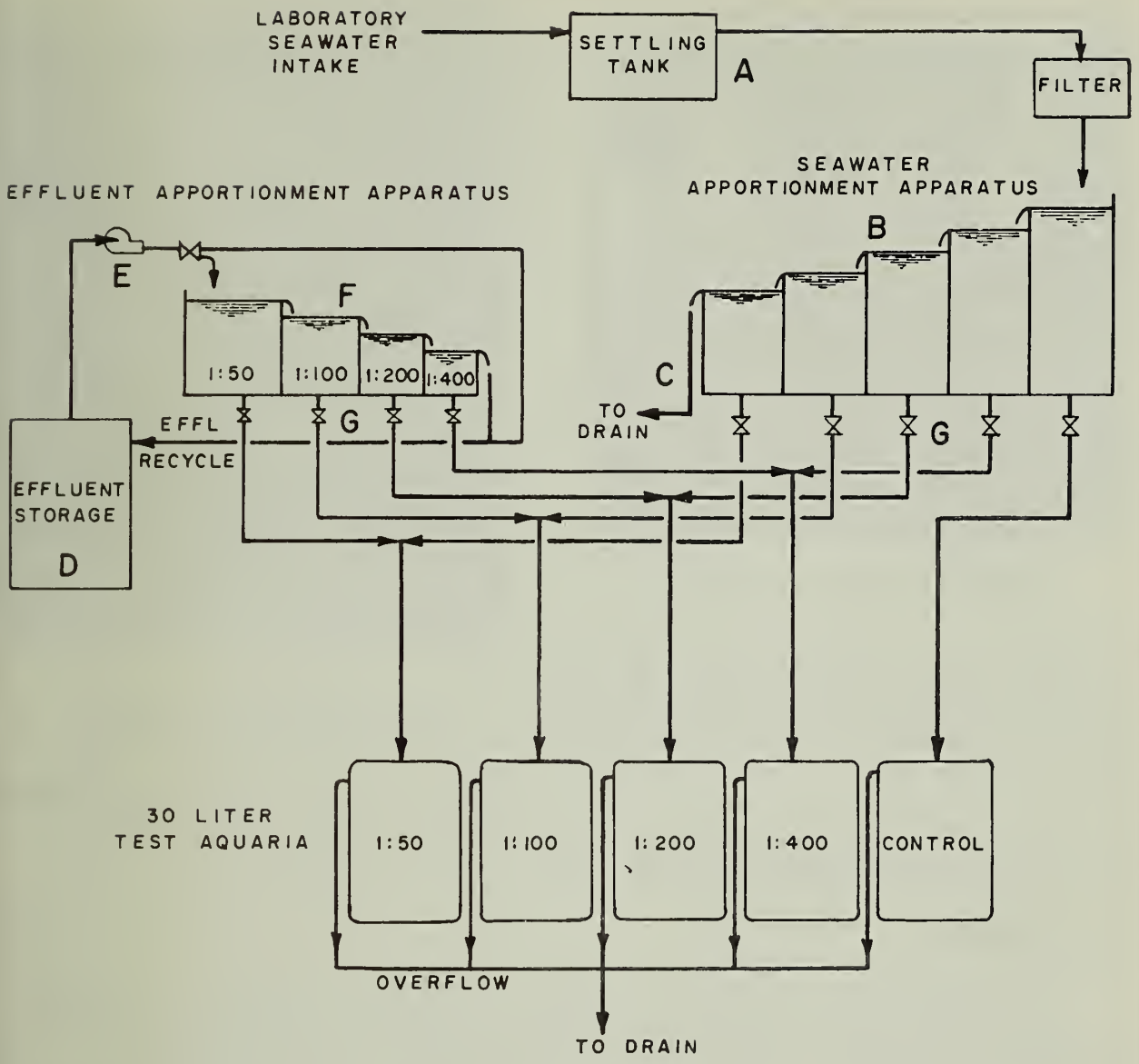


Fig. 3-2. Schematic Diagram of Continuous Flow Serial Dilution Apparatus

Aquaria. The 30-liter aquaria used in the continuous flow apparatus served as holding tanks for egg-bearing female crabs as well as for experimental purposes. These tanks were constructed of plexiglass and were equipped with polyvinylchloride standpipes to maintain a constant water level (Fig. 3-3). The standpipes were covered with No. 4 mesh plankton netting to prevent the loss of any organisms through the drain.

Egg and Zoea Chambers. Special chambers were designed to keep eggs and zoea confined to a small space to facilitate counting while maintaining continuous-flow conditions. The chambers used for zoea (Fig. 3-4) were plexiglass cylinders covered at both ends with No. 4 plankton netting. This system allowed adequate

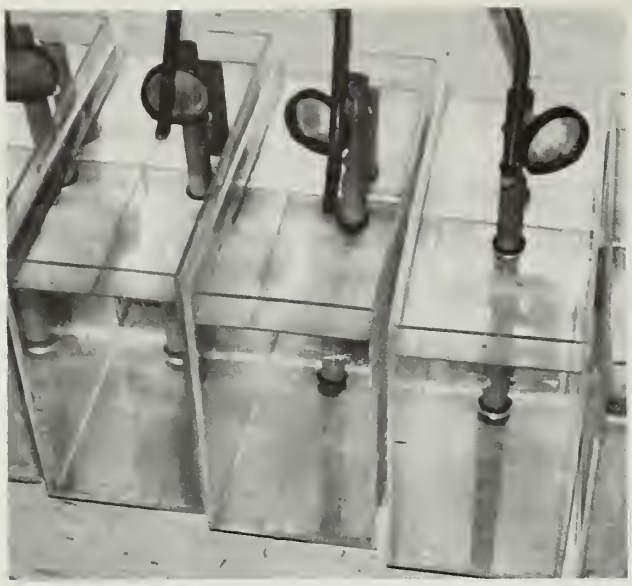


Fig. 3-3. Aquaria, 30 Liter

Fig. 3-4 Zoea Chamber for Continuous-Flow Apparatus

circulation and influx of food organisms, but prevented the escape of zoea. The chambers used for egg experiments were further modified as shown in Fig. 3-5. A funnel was attached to the top of each chamber and an air tube inserted. Air was bubbled into the funnel to provide constant circulation through the chamber. These gentle currents were found necessary to minimize fungal growths on egg masses. It is believed that the water movements more closely approximated natural conditions when the eggs are brooded by the female crab.

Test Organisms

The primary emphasis of the 1971 program was a study of the effects of the waste-water effluents on juvenile stages of the Dungeness crab. To accomplish this task throughout the proposed 6-month period of laboratory study, large numbers of egg-bearing female crabs were obtained in order to provide a constant supply of eggs and larvae. Since egg-bearing females were only available during the spring months in California waters, it was necessary to obtain specimens from as far north as Alaska for the later stages of the investigation.

Most of the crabs were obtained from Westport, Washington or Kodiak Island, Alaska, with the cooperation of commercial fishermen and the appropriate state agencies. The crabs were trapped using standard 48- or 60-inch commercial pots, packed on ice in insulated containers, and transported by air freight. Upon arrival at the laboratory, the crabs were weighed, numbered and marked. They were then categorized according to the development of the egg masses (Fig. 3-6) and placed in the holding tanks for a 5-day acclimatization period.

Fig. 3-5 Egg Chamber for Continuous-Flow Apparatus

In spite of the precautions in handling the crabs from the point of collection until their arrival at the laboratory, approximately 25 percent were dead on arrival. In addition, some of the eggs had already hatched and could not be used for experimentation.

Other species of crabs were collected from the California coast between Tomales Bay and Duncan's Landing. Collection techniques were similar to those described in Vol. I, Chapter 5. The species collected were hermit crabs (Pagurus samuelis), porcelain crabs (Petrolisthes cinctipes), and kelp crabs (Pugettia producta).

The feeding of the crabs depended on their life stage. Adult crabs were fed ground fish or clams; crab zoea were fed brine shrimp larvae. The effectiveness of the latter as a food source was not evaluated, although it has been previously reported that Dungeness crab zoea can be successfully reared with brine shrimp larvae (Poole)[5].

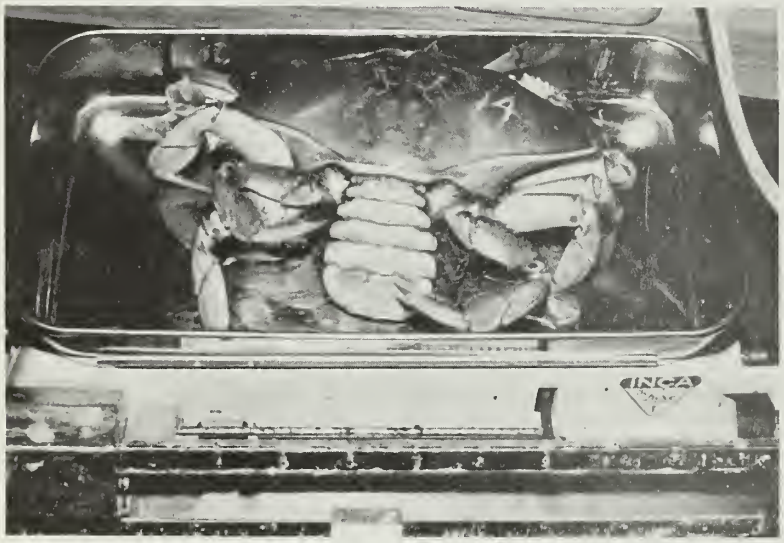
Sample Waters

The samples of wastewater effluent used for the 1971 laboratory investigations were a 50:50 mixture of 24-hour flow-proportional composites taken from the Richmond-Sunset and Southeast water pollution control plants. Effluent from the North Point plant was not included because engineering studies at that time indicated that effluents from the Richmond-Sunset and Southeast plants would probably be combined and discharged through a single submarine outfall into the Gulf of the Farallones. Effluent from the North Point plant would be discharged separately to San Francisco Bay. Toxicity bioassays on effluent from the individual plants showed a generally higher trend in acute toxicity at the Richmond-Sunset and Southeast plants than at the North Point plant. A chemical analysis was made to determine the characteristics of the composite, and the results are presented in Table 3-1.

Data Analysis

The statistical methods used to analyze the experiments reported in this study were analysis of variance techniques patterned after Sokal and Rohlf[8], using the statistical tables by Rohlf and Sokal[7]. A brief summary of each analysis of variance is presented in the results section in the following form:

A. Crabs received on ice



B. Crabs weighed and numbered

C. Egg mass inspected

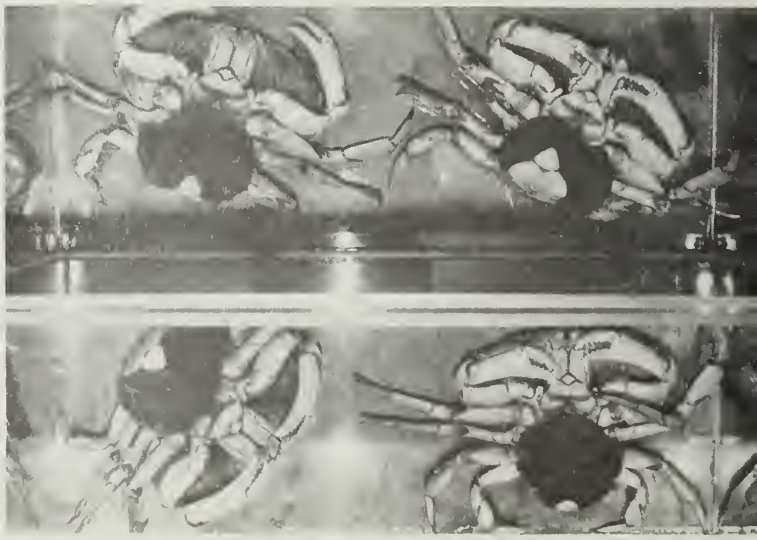


Fig. 3-6. Crab Shipments

Source of variation	df	SS	MS	F_S	$F_{0.05}$	$F_{0.05}$
(A)	a	-	-	-	-	-
(B)	b	-	-	-	-	-

The above format is for a single classification analysis of variance. In this table the sources of the variation are listed as: (a) variation due to treatment effects (among groups); and (b) variation among replicates (experimental error). The terms "df", "SS", and "MS" refer to degrees of freedom, sums of squares, and mean squares, respectively. The "F_S" term is the calculated ratio of the variances among groups to the variances within groups due to experimental errors of replication. The "F_S" term is then compared to the F-value that would be expected by pure chance. This F-value is obtained from the statistical tables. For the purposes of this report, the 95 percent confidence level was accepted as the minimum standard for statistical significance. However, the 90 percent confidence levels were also included. Therefore, the F_S term must be greater than the tabled $F_{0.05}$ with the appropriate degrees of freedom (a,b) for the result to be significant.

The analysis of variance test averages all the variables and, consequently, may fail to detect real differences when real differences exist. For example, the average test may show that the differences existing among the effects of all wastewater dilutions on crab zoea are insignificant and mask the fact that a difference between the control and one particular dilution was significant. However, Fisher[2] who originated this analysis, stated that much caution should be exercised before claiming significance for special comparisons when the average test does not demonstrate significance. As a precautionary measure, we have calculated the 90 percent confidence levels as well as the 95 percent confidence levels. Special attention was given in the borderline cases where the level of significance was approached, but not attained.

Table 3-1. Chemical Characterization of Wastewater Composite Collected From Richmond-Sunset and Southeast Water Pollution Control Plants on April 1, 1971

Determination	mg/l
Chloride (Cl)	586
Total alkalinity ($CaCO_3$)	131
Dissolved residue (evap)	1,400
Suspended matter, total	170
Nitrite (NO_2-N)	0.04
Nitrate (NO_3-N)	0.14
Ammonia (NH_3-N)	20.7
Organic nitrogen (N)	15.4
Total nitrogen (N)	36.2
Total phosphate (PO_4-P)	18
5 day BOD, 20 C	126
COD	434
MBAS	3.2
Grease	51
Specific conductivity (micromhos/cm - 25 C)	2,410
Hydrogen ion concentration (pH)	7.2
Turbidity (JTU)	94
Settleable solids (ml/l/m)	0.2

RESULTS AND DISCUSSION

A summary of the experiments performed during the 1971 laboratory investigations is given in Table 3-2. For purposes of discussion, bioassays on the Dungeness crab (Cancer magister) are presented first, followed by the bioassays on other crab species. The results of each experiment are discussed and analyzed in the text, and the original data are appended (Appendix B). Statistical analyses are shown in Table 3-3.

Table 3-2. List of Laboratory Experiments

Experiment No.		Test method
1	Cancer magister (Dungeness crab), 1st-day zoea	Static
2	Cancer magister, 1st day zoea pre-exposed	Static
3	Cancer magister, consecutive zoea (3rd-7th days)	Static
4	Cancer magister, 1st-day zoea	Static
5	Cancer magister, 1st-day zoea pre-exposed	Static
6	Cancer magister, 1st-day zoea pre-exposed	Static
7	Cancer magister, 5th-day zoea	Static
8	Pagurus samuelis (hermit crab), adults	Continuous-flow
9	Petrolisthes cinctipes (porcelain crab), adults	Continuous-flow
10	Pagurus samuelis, adults	Continuous-flow
11	Cancer magister, megalops and juveniles	Continuous-flow
12	Petrolisthes cinctipes, 1st-day zoea	Continuous-flow
13	Petrolisthes cinctipes, eggs "in vivo"	Continuous-flow
14	Pugettia producta (kelp crab), 2nd-day zoea	Continuous-flow
15	Pugettia producta, 7th-day zoea	Continuous-flow
16	Pugettia producta, 1st-day zoea	Continuous-flow
17	Pugettia producta, 6th-day zoea	Continuous-flow
18	Cancer magister, eggs "in vitro"	Continuous-flow
19	Cancer magister, 1st-day zoea	Continuous-flow

Dungeness Crab Bioassays

Most of the bioassays using Dungeness crabs were performed under static conditions as shown in Table 3-2. This was because of operational difficulties with the continuous-flow systems which were not, unfortunately, corrected until after the supply of Dungeness crabs was depleted. As explained previously, the static tests were modified by exchanging about 75 percent of the water daily in order to more closely approximate the condition of continuous exposure which might occur in the marine environment.

The experiments are grouped in the following sections according to the life stage of the crab tested. Egg bioassays are presented first, followed by experiments on successively older zoea, and finally by the experiment on megalops and juvenile crabs.

Dungeness Crab Eggs

The experiments on Dungeness crab eggs were performed with two objectives: first, to test the effects of various dilutions of the wastewater on the total hatch; and second, to test the influence of wastewater on the occurrence of prezoea. Since it was not possible to predetermine when eggs would hatch, eggs were added to both the control and dilution replicates on three successive days. Thus, an indirect result of these experiments was a test of the effects of wastewater on eggs at different stages of maturity.

Table 3-3. Static and Flow Thru Bioassays, Analysis of Variance

Experiment No.	Source of variation	df	SS	MS	F_s	$F_{0.05}$	$F_{0.10}$
1	Wastewater dilutions	4	973	243	0.74_{ns}	3.48	2.61
	Experimental error	10	3270	327			
2	Wastewater dilutions	4	440	110	0.55_{ns}	3.48	2.61
	Experimental error	10	2000	200			
3	Wastewater dilutions	4	1460	365	0.88_{ns}	3.01	2.33
	Age of zoea	4	17400	4350	10.56*		
	Experimental error	16	6580	411			
4	Wastewater dilutions	4	1130	282	1.01_{ns}	3.48	2.61
	Experimental error	10	2800	280			
5	Wastewater dilutions	4	400	100	2.00_{ns}	5.19	3.52
	Experimental error	5	250	50			
6	Wastewater dilutions	4	1140	285	0.98_{ns}	5.19	3.52
	Experimental error	5	1460	292			
7	Wastewater dilutions	4	760	190	0.89_{ns}	3.48	2.61
	Experimental error	10	2130	213			
14	Wastewater dilutions	2	867	433	0.172_{ns}	5.14	3.46
	Experimental error	6	15100	2520			
15	Wastewater dilutions	3	7290	2430	16.2*	4.07	2.92
	Experimental error	8	1200	150			
16	Wastewater dilutions	4	7700	1920	1.57_{ns}	5.19	3.52
	Experimental error	5	6100	1220			
18a	Wastewater dilutions	3	189	63.0	0.071_{ns}	3.71	2.73
	Experimental error	10	8760	875			
18b Exposure of zoea vs dilution	Wastewater dilutions	3	15.3	5.10	1.97_{ns}	4.76	3.29
	Exposure	2	14.2	7.10	2.74_{ns}	5.14	3.46
	Experimental error	6	15.5	2.60			
19	Wastewater dilutions	3	780	927	2.56_{ns}	3.24	2.46
	Experimental error	16	5800	362			

df = Degrees of freedom.
SS = Sum of squares.
MS = Mean square.
F_s = F value.
$F_{0.05}$ = Tabled F value at 95 percent confidence level.
$F_{0.10}$ = Tabled F value at 90 percent confidence level.
ns = Not significant at 95 percent confidence level.
* = Significant at 95 percent confidence level.

The continuous-flow apparatus with the specially designed egg chambers was used for these experiments. Eggs were removed from the female crab on three consecutive days and placed into the chambers for incubation in wastewater dilutions of 1:200, 1:100, 1:50, and a control of seawater. It was not possible to count the number of eggs accurately because of the stress that would be placed on them from excessive handling. Therefore, a system was devised whereby a standard volume of eggs was used as an inoculum.

The results of the experiments showed a substantial variation in the number of eggs hatched, but by assuming that any errors introduced by measuring the eggs volumetrically rather than by direct counts were of a random nature, it was determined that there were no significant differences in total egg hatches due to different dilutions of wastewater. The results of the statistical analysis (Experiment 18, Table 3-3) show that the F_s value of 0.071 is less than the F value from the statistical tables and is not significant.

One of the important aspects of this study was the possible effects of wastewater on the occurrence of prezoea. A rather high percentage of the eggs which hatched remained in the prezoeal life stage and did not molt to zoea. The analysis of variance test using a two-way classification was used to determine if either the wastewater dilutions or the length of exposure before hatching had any effect on the occurrence of prezoea. The results of the analysis showed that neither the wastewater dilutions nor the exposure time were significant (Experiment 18, Table 3-3). This can be interpreted to mean that under the conditions of the bioassay test, prezoea were as likely to occur in the seawater controls as in any of the wastewater dilutions.

There has been some disagreement among previous investigators as to whether or not prezoea are a viable life stage. The incidence of prezoea in the hatching of Dungeness crab eggs was described by MacKay[3] as a normal short-term stage of the larval development. However, Mir[4] and Poole[5] both observed prezoea and described them as being abnormal and according to Mir, terminal. Further studies by Buchanan and Millemann[6] indicated that a prezoeal stage did occur, but was of short duration. They also found that stress conditions, such as temperature or salinity changes, could induce the occurrence of abnormally high numbers of prezoea which would not molt to zoea. These results are in accord with the results of the present study, since there was a high occurrence of prezoea and none were observed to molt to zoea. In view of the fact that neither the wastewater dilutions nor the exposure time had any significant effect on the occurrence of prezoea, it is likely that the relatively high occurrence of prezoea was due to the stress conditions inherent to the bioassay tests or in the handling of the egg-bearing crabs prior to the tests.

Dungeness Crab Zoea

Dungeness crab zoea were tested in a series of experiments with the objective of measuring the effects of wastewater on zoea of different ages and history. Most of these experiments were static bioassays because of the aforementioned difficulties with the continuous-flow apparatus.

First-Day Zoea Hatched in Seawater. First-day zoea hatched in seawater were tested using wastewater dilutions of 1:200, 1:100, 1:50, 1:20, and a seawater control. Ten zoea were placed in each of three replicate 250 ml bowls and incubated for four days. The number of survivors were recorded daily. The data were analyzed by analysis of variance (Experiment 1, Table 3-3), and the results showed that wastewater dilutions did not significantly affect the survival of zoea.

The experiment was repeated using the same procedure except that only two replicates of each dilution were tested. The results were analyzed (Experiment 5, Table 3-3) and again no significant effects of wastewater dilutions on the survival of the zoea were noted.

Another experiment was performed with first-day zoea, (Experiment 19, Table 3-3) and the continuous-flow apparatus was used. Ten zoea were placed in the zoea chambers in tanks with wastewater dilutions of 1:200, 1:100, 1:50, and a seawater control. After four days, there were no significant differences among the control and the various dilutions at the 95 percent confidence level. However, the result was significant at the 90 percent confidence level.

First-Day Zoea Hatched in Diluted Wastewater. A series of three experiments were performed using first-day zoea hatched in wastewater dilutions of 1:20, 1:100, and 1:200. The eggs were removed from the female crab and placed in the respective wastewater dilutions until one day after hatching. The zoea were then removed and used for the bioassay. Procedures used were the same as in the experiments described above. The results from the first-day zoea hatched in 1:20, 1:100 and 1:200 wastewater dilutions are shown in Table 3-3 (Experiments 2, 4, and 6, respectively). Again there were no significant effects of the wastewater dilutions on the survival of the zoea in any of the experiments. Although not tested statistically, a comparison of the results among the three experiments indicated that the history of the zoea (i.e., hatching in various wastewater dilutions) did not have an effect on the results.

Third- to Seventh-Day Zoea. An experiment was designed to test whether or not wastewater would affect zoea of different ages. Zoea hatched in seawater from the eggs of a single female crab were used. Ten third-day zoea were placed in 250 ml bowls containing wastewater dilutions of 1:200, 1:100, 1:50, 1:20, and a seawater control. The following day fourth-day zoea were started in the same manner, and the procedure was continued until seventh-day zoea were used. The bowls were incubated at 11 to 13 C for four days with daily checks on survival. The results were recorded at the end of four days and analyzed using an analysis of variance with a two-way classification (Experiment 3, Table 3-3). The analysis shows that the wastewater dilutions had no significant effect on survival, but age of the zoea used in the experiment was highly significant (i.e., significant at the 99.9 percent level). Examination of the data of Experiment 3 (Table 3-4) reveals that survival was extremely low (20 percent or less) when sixth- or seventh-day zoea were used. Since there was no survival in the controls in either case, it is unlikely that the cause of the mortality was the wastewater.

Since there was also a high mortality (80 percent) in the control with the fifth-day zoea, another test with fifth-day zoea was performed using the same procedure as above. Survival was higher in the controls (60 to 80 percent after four days), but there was still no significant effect due to the wastewater dilutions as shown in Experiment 7, Table 3-3.

The literature concerning the life history of the Dungeness crab was reviewed in an attempt to explain the high mortality among the sixth- and seventh-day zoea.

Table 3-4. Experiment 3. Percent Survival of Dungeness Crab Zoea Three to Seven Days Old After 96 Hours in Wastewater Dilutions

Beginning age of zoea, days	Wastewater dilution				
	Control	1:200	1:100	1:50	1:20
3	50	40	50	60	70
4	70	50	50	80	0
5	20	60	70	100	80
6	0	0	0	0	10
7	0	10	10	10	0

Poole[5] and Reed[6] both observed that zoea undergo several molts before reaching adult stage. The timing of each molt is dependent on several environmental conditions, of which the most important seems to be temperature. At the temperatures used in the experiments conducted during this study, it would be expected that the molt would occur sometime during the four-day experiment (from Poole[5] and Reed[6]). An indication that molting had occurred during the experiments was the presence of cast skins in the bottom of the zoea chambers.

The molting process is apparently a period of great stress which results in high mortality. Poole[5], Reed[6], and Buchanan[1] found that antibiotics or sterile background water were necessary to rear zoea through successive molts without high mortality because fungal and bacterial infections tended to reduce survival. Because antibiotics were not used in the present study to control fungus and bacteria, it is possible that the mortality was due to fungal or bacterial infection. In any case, sensitivity during the molting process appears to be the best explanation for the high mortality observed among sixth- and seventh-day zoea during the course of the experiment. The same phenomenon of high mortality during the first molt was observed in the 1970 laboratory studies reported in Volume I.

Megalops and Juvenile Dungeness Crabs. Megalops, which are the final larval stage in the development of the crabs, were used to test wastewater effects on advanced stages of Dungeness crabs. The megalops were collected about four miles west of Bodega Head using a No. 2 mesh plankton net. A continuous-flow apparatus was used, and nine megalops each were placed in wastewater dilutions of 1:100, 1:50, and a seawater control. Within 48 hours, all the megalops molted into juvenile crabs which were then incubated for 50 days. Survival at the termination of the experiment (50 days) was 55.5, 66.7, and 66.7 percent for the control, and the 1:100 and 1:50 dilutions, respectively. Measurements across the carapace at the widest point were made, and the mean values were 11.8, 10.7, and 9.8 mm for the control, 1:100 and 1:50 dilutions, respectively (Table 3-5). Because of the small sample size and other variables involved in using crabs of different backgrounds, it is impossible to determine if the differences among these means are significant.

Dungeness Crab Bioassay Summary

Bioassays with Dungeness crabs did not produce any evidence that the San Francisco municipal wastewater effluent has any adverse effect on the crabs at any of the dilutions tested. Results of experiments on eggs from Dungeness crabs exposed to wastewater dilutions ranging in strength from seawater to 1:50 waste-

Table 3-5. Carapace Width of Juvenile Cancer Magister Crabs After 50 Days Exposure to Dilutions of Wastewater

Width in mm		
Control	1:100	1:50
13	11	11
11	11	10
12	12	9
12	10	10
11	10	10
	10	9

water: seawater show no significant differences among the eggs hatched in seawater or diluted wastewater. The occurrence of prezoea could not be attributed to wastewater but is believed to result from stress conditions. Similarly, no significant effects of wastewater could be detected on first-day zoea which had been hatched in either seawater or dilutions of wastewater ranging from 1:20 to 1:200. Experiments were also conducted to test zoea of various ages, ranging from three to seven days old, in various dilutions of wastewater, and again no effects attributable to wastewater were found. The sixth- and seventh-day larvae had high mortality rates during the experiment, but this is believed to have been caused by stress occurring during the molting process. The final experiment on megalops indicated that crabs grown for 50 days in wastewater dilutions of 1:100 and 1:50 were slightly smaller than those grown in the controls. However, because of the small sample size, these results were not analyzed statistically.

Bioassays on Other Species of Crab

Bioassays were performed on other crab species including hermit crabs (Pagurus samuelis), porcelain crabs (Petrolisthes cinctipes), and kelp crabs (Pugettia producta), when Dungeness crabs were unavailable. These experiments were performed using the continuous-flow apparatus.

Hermit Crabs. Adult hermit crabs were tested in two experiments with a wastewater dilution ranging from 1:400 to 1:50 plus a seawater control. In each, ten crabs were placed in the test apparatus and incubated for four days. All crabs survived in the first experiment, but in the second experiment, two crabs died in the 1:200 dilution and one in the 1:100 dilution. Results of this experiment produced no evidence to suggest that the wastewater affected the survival of the hermit crabs.

Porcelain Crabs. Three experiments were performed with various life stages of porcelain crabs. Adult porcelain crabs were placed in wastewater dilutions of 1:400, 1:200, 1:100, 1:50, and 1:20 plus a seawater control (Experiment 9). Survival after four days was 90 to 100 percent, indicating no adverse effects from the wastewater.

Eggs from the porcelain crab were tested (Experiment 12), but the results were inconclusive. Eggs hatched in the control and 1:50 and 1:20 wastewater dilutions, but not in the 1:400 or 1:100 dilutions. In many instances, the eggs became cloudy and decomposed. Since decomposition occurred in the control as well as in the various wastewater dilutions, this phenomenon was not attributable

to the presence of wastewater. Most of the eggs that did hatch were zoea rather than prezoea. The high occurrence of prezoea observed in the experiments on Dungeness crab eggs did not recur here.

Finally, first-day zoea, hatched in seawater, were incubated in the continuous-flow apparatus at wastewater dilutions of 1:400, 1:200, 1:100, 1:50, and a seawater control (Experiment 13). Survival after four days was 70 to 90 percent, and again there were no adverse affects attributable to the wastewater dilutions.

Kelp Crab. Four experiments were performed using zoea from the kelp crab, Pugettia producta. All were performed with the continuous-flow apparatus using the same procedures employed in the previous experiments.

In the first experiment (Experiment 16, Table 3-3), first-day zoea were placed at wastewater dilutions of 1:400, 1:200, 1:100, 1:50, and a seawater control. Survival after four days ranged from 67 to 100 percent. Survival was substantially lower after eight days, dropping to zero in the 1:50 dilution. However, problems with algal and fungal growth in the test chambers caused the results to be erratic. Thus the analysis of variance test (Experiment 16, Table 3-3) showed that there were no significant effects due to the wastewater dilutions.

Second-day zoea were tested at wastewater dilutions of 1:200 and 1:50 plus a control (Experiment 14, Table 3-3). Survival after four days ranged from 0 to 100 percent, but there was no discernible pattern in the data. Sixth- and seventh-day zoea were also tested in two subsequent experiments. The experiment testing sixth-day zoea (Experiment 17, Appendix B) was terminated after four days with survival ranging from 47 to 93 percent. The seventh-day zoea (Experiment 15, Table 3-3) were incubated for 12 days at which time mortality was 100 percent. Survival in the latter experiment ranged from 0 to 90 percent after four days, but the lowest survival occurred in the control and the 1:50 dilution. Thus, it was not possible to interpret the results.

CONCLUSIONS

Upon completion of the field and laboratory studies described in Volume I, a series of ecological design criteria were presented as a guide for the discharge of primary-treated municipal wastes to the waters of San Francisco Bay and the Gulf of the Farallones. The most important criteria concerning the physical design of an outfall were related to dilution. Dilution design criteria were established through the following steps:

1. The marine biota tested in the 1970 laboratory program were divided into three groups defined by habitat as the intertidal community, the benthic community, and the open water community.

2. The effluent dilution required to assure 90 percent survival after 96 hours exposure of the most sensitive test organisms in each community was determined. If no mathematical determination

could be made of dilution required for 90 percent survival, the highest dilution which appeared to demonstrate a detectable effluent response was selected.

3. A safety factor of 10 was applied to the dilution determined in (2) above, and the resulting dilution was set as the minimum design dilution for long-term exposure of each community to a waste field.

Following these steps, a dilution criterion of 1:100 was selected for the shoreline community, 1:500 for the benthic community, and 1:200 for the water column community. In the latter case a dilution of 1:100 was considered adequate for exposures of less than 24 hours. The dilution of 1:500 for the benthic community was selected on the basis of dungeness crab hatching experiments, and the egg-bearing Dungeness crab was therefore the indicator organism.

Based on recommendations of the City's Technical Advisory Board, one primary purpose of the laboratory work described in Volume III was to further define the effect of municipal effluents on Dungeness crab eggs and larvae. As reported in this chapter, the laboratory work conducted during 1971 produced no evidence to indicate that the ecological design criteria previously established should be changed. Statistical tests of the experimental data generally showed that at the 95 percent confidence level the effect of wastewater dilutions was not significant. The wastewater dilutions tested included dilutions of 1:50 and, in some cases, 1:20. Therefore, the recommended dilution factor of 1:500 for protection of egg-bearing Dungeness crabs provides a safety factor of at least 10 to 1 and probably more.

The 1971 laboratory work was conducted using seawater from the open California coast for control and dilution water, while the 1970 work was conducted using dilution water typical of the outflow from San Francisco Bay. The 1971 tests included both modified static and continuous flow bioassays, while the 1970 work consisted principally of static bioassays. The 1971 laboratory work thus confirms under different test conditions the basic conclusion drawn from the earlier work, which is that the toxicity of primary treated municipal effluent is not a cause for concern if an outfall is properly located and adequate dilution is achieved.

CHAPTER 4

SUMMARY OF FINDINGS AND CONCLUSIONS

Following the completion of physical and biological oceanographic studies for the Predesign Report on Marine Disposal for the City and County of San Francisco, supplemental ecological investigations were found to be needed. These were necessary to augment data obtained on the presence of Dungeness crab, in both larval and adult form, in the Gulf of the Farallones and to confirm bioassay data on the response of these crab larvae to diluted effluent from the City's sewage treatment plants.

The supplemental work was authorized in November 1970 and comprised a delineation of a study area in an offshore zone best suited for marine disposal of treated wastewater; a program of zooplankton sampling and identification of crab larvae, particularly Dungeness crab larvae, in the study area; and a sampling program for adult crabs. Laboratory investigations on the response of crab larvae to effluent utilized both static and continuous- flow bioassay techniques with ocean water from an unpolluted source used as background water. Also the possible causes of the emergence of terminal prezoea, a larval form, were investigated.

Field Investigations

The field investigations and their findings may be summarized as follows:

1. A study area was chosen offshore from Ocean Beach, just south of the main ship channel through the bar and extending southward about four miles. Six sampling stations, five of which were at permanent navigation buoys, were designated. The study area lies on the Golden Gate bar and is subject to fast tidal currents.

2. Six cruises for plankton sampling were made between January 21 and April 14, 1971 and comprised of 74 tows, 39 at a depth of one meter and 35 at eight meters.

3. Total zooplankton counts in all samples ranged from zero to 20,300 per cubic meter (cu m).

4. In the 74 samples, 929 crab larvae were found, 80 of which were *Cancer* crabs but only two of which were positively identified as *Cancer magister* (Dungeness) larva.

5. The average concentration of crab larva was 28 per cu m at the eight meter depth compared to 11 per cu m at one meter.

6. Cancer crab larva were relatively more abundant in late March and mid-April than earlier in the year.

7. Total zooplankton were present in the same order of magnitude as in 1970.

8. Adult crab sampling was undertaken in the study area between January 21 and April 22 by means of 21 settings of baited crab pots with escape hatches for small female crabs closed.

9. A total of 86 crabs were collected of which 64 were Cancer magister.

10. Of the Cancer magister crabs collected, 59 were males and five were females, only one of which was egg-bearing.

11. Other species collected were Cancer productus and Cancer antennarius. Of these, only four of a total of 22 were males.

12. The average catch varied widely with respect to station and to time.

13. The California Department of Fish and Game started special crab collection and enumeration programs in the Gulf of the Farallones in late 1971.

14. Two DFG stations were within the City study area. Three samples were obtained, two in December 1971 and one in January 1971, encompassing 86 trap settings.

15. The three DFG trappings collected 393 Dungeness crabs, including 382 males and 11 females. All females were egg-bearing or had recently spawned.

16. The average DFG catch was 4.5 crabs per trap, but an average of only 1.7 lb per trap was of legal size.

17. Staff of the Department of Fish and Game at the Menlo Park office state that female Dungeness crab do not eat bait while egg-bearing and hence the low number of females in the traps does not necessarily indicate a low number in the area. They also cited evidence of rather wide range movements of crab about the Gulf of the Farallones, as gathered through a crab-tagging program.

18. Commercial crab fishermen who were interviewed stated that the most productive areas have moved farther and farther offshore over the past ten years. However, the staff of the Department of Fish and Game did not agree with this observation.

Laboratory Investigations

The laboratory investigations and their findings may be summarized as follows:

1. The 1971 bioassay program was conducted at the Bodega Marine Laboratory of the University of California.

2. The work program included both modified static and continuous-flow experiments.

3. Primary emphasis was given to bioassays of the eggs, larvae, and juveniles of Dungeness crab. Hermit crabs, porcelain crabs, and kelp crabs were also tested in larval and adult forms.

4. Bioassays were conducted using composited effluent from the Richmond-Sunset and Southeast Water Pollution Control Plants and dilution water from the Pacific Ocean adjacent to Bodega.

5. Experimental results were tested by analysis of variance techniques to determine statistical significance.

6. Experiments on Dungeness crab eggs showed no significant difference in egg hatch due to effluent dilutions as low as 1:20.

7. A high percentage of prezoea was observed in all Dungeness crab egg hatches, but neither the wastewater dilution nor the length of exposure had any significant effect on prezoea occurrence.

8. Bioassays of first-day Dungeness crab zoea in effluent dilutions as low as 1:20 showed no statistically significant effect of the wastewater. This was true both for zoea hatched in seawater and for zoea hatched in wastewater at dilutions as low as 1:20.

9. Dungeness crab zoea aged three to seven days were tested in bioassays with dilutions of wastewater as low as 1:20. The wastewater did not significantly affect survival.

10. A high mortality rate occurred in Dungeness crab zoea at the first molt whether or not the zoea were exposed to wastewater.

11. Dungeness crab megalops and juveniles were exposed to effluent dilutions of 1:100 and 1:50 for 50 days. The effluent did not affect survival but may have had a slightly adverse effect on the growth rate.

12. Adult hermit crabs were exposed to effluent dilutions as low as 1:50 without significant effect.

13. Porcelain crab adults and eggs were exposed to effluent dilutions as low as 1:20. There was no significant effect of effluent on either adult survival

or egg hatch. The occurrence of prezoea was much lower than in experiments with Dungeness crab eggs.

14. Porcelain crab first-day zoea were tested in effluent dilutions as low as 1:50 without significant adverse effect.

15. Kelp crab zoea of different ages were tested in four experiments at effluent dilutions as low as 1:50. There was no adverse effect attributable to the wastewater after four days, but survival decreased in the wastewater after eight days.

CONCLUSIONS

Conclusions drawn from the field and laboratory investigations are as follows:

1. The 1971 plankton sampling program tends to confirm the validity of the 1970 program.

2. The results from both 1970 and 1971 plankton studies reflect the low population of Dungeness crab in the Gulf of the Farallones.

3. The concentration of Dungeness crab larvae in the study area does not differ significantly from that in the Gulf of the Farallones as a whole.

4. The most abundant adult Cancer crab in the study area during the winter of 1971-72 was the Dungeness crab.

5. Fluctuations in catch may have resulted from movement of crabs into and out of the study area.

6. Evidence with respect to mass water movements, occurrence of Dungeness crab larva, and adult crabs in the study area do not refute the concept that the study area is a special nursery ground for Dungeness crab.

7. Interviews with veteran commercial crab fishermen reveal that the study area was productive in the past but has played only a minor role in total crab production since 1965.

8. We conclude that the study area could again become an important crab fishery area upon return of the Dungeness crab to past population levels in the Gulf of the Farallones and that the area must therefore provide appropriate protection for all stages of the Dungeness crab.

9. Laboratory tests conducted on adults, juveniles, larvae, and eggs of four species of crabs, with primary emphasis on Dungeness crab, showed no statistically significant effect due to wastewater dilutions ranging from 1:400 to 1:20.

10. The results of the 1971 laboratory studies generally confirm the results of the 1970 laboratory studies.

11. We conclude that the ecological design criteria developed at the end of the 1970 work and presented in Volume I are still valid.

12. The 1971 laboratory work reinforces the basic finding of the 1969-70 study, which is that primary effluent discharged from the City of San Francisco at appropriate points through properly designed submarine diffusers will not adversely affect the marine environment of the Central Bay or the Gulf of the Farallones.

REFERENCES

1. Buchanan, D. V., and R. E. Millemann, "The Prezoeal Stage of the Dungeness Crab, Cancer magister, Biological Bulletin, 137: 250-255, 1969.

2. Fisher, R. A. 1935. In - Snedecor, G. W. and W. G. Cochran, "Statistical Methods, Iowa State University Press, Ames, Iowa. 1967.

3. MacKay, D. C. 1934. "The Growth and Life History of the Pacific Crab, Cancer magister Dana", Unpub. Doctoral thesis, Stanford University, Palo Alto, 1934.

4. Mir, R. D. "The External Morphology of the First Zoeal Stages of the Crabs, Cancer magister Data, Cancer antennarius Stimpson, and Cancer anthonyi Rathburn", California Fish and Game Quarterly 47: 103-111, 1961.

5. Poole, R. L., "A Description of Laboratory-reared Zoea of Cancer magister Dana and Megalopae Taken Under Natural Conditions (Decapoda, Brachyura)", Crustaceana 11: 83-97, 1966.

6. Reed, P. H., "Culture Methods and Effects of Temperature and Salinity on Survival and Growth of Dungeness Crab (Cancer magister) Larvae in the Laboratory, Journal Fisheries Research Board, Canada 26: 389-397, 1969.

7. Rohlf, F. J. and R. R. Sokal, "Statistical Tables", W. H. Freeman and Company, San Francisco, 1969.

8. Sokal, R. R. and F. J. Rohlf, "Biometry", W. H. Freeman and Company, San Francisco, 1969.

APPENDIX A

PLANKTON ANALYSES

PLANKTON ANALYSIS

N 1 DATE January 21, 1971 COLLECTED BY L. Birke LAB NO. 289

PE Surface TOW LENGTH 5 min ANALYZED BY E. Wilson

E CONCENTRATED PREDOMINANT
ED (M^3) 11.45 VOLUME (ml) 32 ALIQUOT (ml) 3.2 ORGANISMS COPEPODS

ER OF NUMBER OF DIVERSITY
ISMS/M^3 1240 SPECIES 6 INDEX 0.70

ICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ANOID COPEPODS	69	603		
LOPOID COPEPODS	34	298		
PACTICOID COPEPODS	17	148		
NACLE NAUPLII	3	26		
VACEANS (OIKOPLEURA)	13	113		
INODERM LARVAE	6	52		
	142	1,240		
B ALIQUOT				
otal BRACHYURA ZOEA	0/total sample	0		
ANCER MAGISTER	0			
ANCER spp.	0			

PLANKTON ANALYSIS

STATION 6 DATE January 21, 1971 COLLECTED BY L. Birke LAB NO. 299

TOW TYPE Surface TOW LENGTH 5 min ANALYZED BY A. Mahood

VOLUME SAMPLED (M^3) 12.65 CONCENTRATED VOLUME (ml) 32 ALIQUOT (ml) 2 PREDOMINANT ORGANISMS COPEPODS

NUMBER OF ORGANISMS/M^3 802 NUMBER OF SPECIES 8 DIVERSITY INDEX 0.77

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
CALANOID COPEPODS	367	463		
CYCLOPOID COPEPODS	113	143		
HARPACTICOID COPEPODS	25	32		
COPEPOD NAUPLINN	12	16		
BARNACLE NAUPLII	8	10		
LARVACEANS (OIKOPLEURA)	41	52		
ECHINODERM LARVAE	66	83		
BRACHYURAN LARVAE	2	3		
	634	802		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA	62/total sample	78		
CANCER MAGISTER	0			
CANCER spp.	2	3		

PLANKTON ANALYSIS

ATION 2 DATE February 8, 1971 COLLECTED BY L. Birke LAB NO. 247

W TYPE Surface TOW LENGTH 5 min ANALYZED BY R. Joslin

LUME MPLED (M^3) 2.6 CONCENTRATED VOLUME (ml) 62 ALIQUOT (ml) 10 PREDOMINANT ORGANISMS COPEPODS

MBER OF GANISMS/M^3 1526 NUMBER OF SPECIES 13 DIVERSITY INDEX 1.83

NTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ANNELIDS	10	24		
CALANOID COPEPODS	297	707		
CYCLOPOID COPEPODS	104	247		
HARPACTICOID COPEPODS	15	36		
COPEPOD NAUPLII	129	307		
BARNACLE NAUPLII	14	33		
FISH LICE	2	5		
CHAETOGNATHS	3	7		
LARVACEANS (OIKOPLEURA)	50	119		
FISH LARVAE	1	2		
PELECYPOD LARVAE	10	24		
DECAPOD ZOEA	2	5		
BRACHYURAN ZOEA	4	10		
	641	1,526		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA				
in 10/62 of sample	4	9		
CANCER MAGISTER	0	0		
CANCER spp.	2	5		

PLANKTON ANALYSIS

STATION 1 DATE February 3, 1971 COLLECTED BY L. Birke LAB NO. 301

TOW TYPE Surface TOW LENGTH 5 min ANALYZED BY R. Joslin

VOLUME SAMPLED (M^3) 3.7 CONCENTRATED VOLUME (ml) 32 ALIQUOT (ml) 3.2 PREDOMINANT ORGANISMS BARNACLE NAUPLII

NUMBER OF ORGANISMS/M^3 5378 NUMBER OF SPECIES 12 DIVERSITY INDEX 1.28

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ANNELIDS	20	54		
CALANOID COPEPODS	304	823		
CYCLOPOID COPEPODS	560	1,513		
HARPACTICOID COPEPODS	15	41		
COPEPOD NAUPLII	50	135		
BARNACLE NAUPLII	955	2,582		
LARVACEANS (OIKOPLEURA)	25	68		
CHAETOGNATHS	5	13		
PELECYPOD LARVAE	45	123		
GASTROPOD LARVAE	5	13		
EUPHAUSID	5	13		
BRACHYURAN ZOEA	1			
	1,990	5,378		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA in 30% of sample	1	1		
CANCER MAGISTER	0	0		
CANCER spp.	0	0		

PLANKTON ANALYSIS

ON 1 DATE January 21, 1971 COLLECTED BY L.Birke LAB NO. 303

YPE Surface TOW LENGTH 5 min ANALYZED BY R. Joslin

ME LED (M^3) 12.2 CONCENTRATED VOLUME (ml) 32 ALIQUOT (ml) 3.2 PREDOMINANT ORGANISMS COPEPODS

ER OF NISMS/M^3 121 NUMBER OF SPECIES 8 DIVERSITY INDEX 1.46

FICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
LANOID COPEPODS	67	55		
CLOPOID COPEPODS	38	31		
PACTICOID COPEPODS	19	16		
PEPOD NAUPLII	1	1		
RNACLE NAUPLII	6	5		
RVACEANS (OIKOPLEURA)	8	6		
INODERM LARVAE	8	6		
IATODE	1	1		
	148	121		
B ALIQUOT				
otal BRACHYURAN ZOEA	0/total sample	0		
ANCER MAGISTER	0			
ANCER spp.	0			

PLANKTON ANALYSIS

STATION 6 DATE January 21, 1971 COLLECTED BY L. Birke LAB NO. 302

TOW TYPE 8 Meters TOW LENGTH 5 min ANALYZED BY A. Mahood

VOLUME SAMPLED (M^3) 12.5 CONCENTRATED VOLUME (ml) 32 ALIQUOT (ml) 1.6 PREDOMINANT ORGANISMS COPEPODS

NUMBER OF ORGANISMS/M^3 915 NUMBER OF SPECIES 10 DIVERSITY INDEX 0.99

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ANNELIDS	2	3		
CALANOID COPEPODS	275	440		
CYCLOPOID COPEPODS	135	216		
HARPACTICOID COPEPODS	93	149		
COPEPOD NAUPLII	21	33		
ISOPODS	1	2		
PELYCEPODA LARVAE	7	11		
ECHINODERM LARVAE	7	11		
LARVACEANS (OIKOPLEURA)	25	40		
BARNACLE NAUPLII	6	10		
	572	915		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA	263/total sample	21		
CANCER MAGISTER	0			
CANCER spp.	7	1		

PLANKTON ANALYSIS

TION 1 DATE February 3, 1971 COLLECTED BY L. Birke LAB NO. 273

TYPE Surface TOW LENGTH 5 min ANALYZED BY A. Mahood

UME IPLED (M^3) 3.35 CONCENTRATED VOLUME (ml) 188 ALIQUOT (ml) 12 PREDOMINANT ORGANISMS COPEPODS

BER OF ANISMS/M^3 2446 NUMBER OF SPECIES 9 DIVERSITY INDEX 1.28

TIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
NNELIDS	18	84		
ALANOID COPEPODS	136	636		
YCLOPOID COPEPODS	192	895		
ARPACTICOID COPEPODS	12	56		
OPEPOD NAUPLII	24	112		
ARNACLE NAUPLII	130	606		
ARVACEANS (OIKOPLEURA)	10	47		
UPHAUSID	1	5		
RACHYURAN ZOEA	1	5		
	524	2,446		
RAB ALIQUOT				
Total BRACHYURAN ZOEA				
in 20/100 of sample	5	7		
CANCER MAGISTER	0	0		
CANCER spp.	1	2		

PLANKTON ANALYSIS

STATION 1 DATE February 3, 1971 COLLECTED BY L. Birke LAB NO. 271

TOW TYPE 8 Meter TOW LENGTH 5 min ANALYZED BY E. Wilson

VOLUME SAMPLED (M^3) 3.5 CONCENTRATED VOLUME (ml) 176 ALIQUOT (ml) 20 PREDOMINANT ORGANISMS COPEPODS

NUMBER OF ORGANISMS/M^3 1740 NUMBER OF SPECIES 10 DIVERSITY INDEX 1.21

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ANNELIDS	52	131		
CALANOID COPEPODS	345	867		
CYCLOPOID COPEPODS	121	305		
HARPACTICOID COPEPODS	98	247		
COPEPOD NAUPLII	33	83		
BARNACLE NAUPLII	29	73		
BARNACLE CYPRIS	3	8		
LARVACEANS (OIKOPLEURA)	7	18		
PELECYPOD LARVAE	3	8		
BRACHYURAN ZOEA	3	8		
	694	1,740		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA in 31% of sample	1	1		
CANCER MAGISTER	0	0		
CANCER spp.	0	0		

PLANKTON ANALYSIS

ION 1 DATE February 3, 1971 COLLECTED BY L. Birke LAB NO 275

TYPE 8 Meters TOW LENGTH 5 min ANALYZED BY E. Wilson

UME PLED (M³) 3.5 CONCENTRATED VOLUME (ml) 76 ALIQUOT (ml) 20 PREDOMINANT ORGANISMS COPEPODS

BER OF ANISMS/M³ 3284 NUMBER OF SPECIES 12 DIVERSITY INDEX 1.35

TIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M³		
NNELIDS	33	36		
ALANOID COPEPODS	1,614	1,751		
YCLOPOID COPEPODS	458	497		
ARPACTICOID COPEPODS	633	687		
OPEPOD NAUPLII	225	244		
ARNACLE NAUPLII	25	27		
ARNACLE CYPRIS	8	9		
UMACEAN	3	3		
ARVACEANS (OIKOPLEURA)	17	18		
ELECYPOD LARVAE	8	9		
RACHYURAN ZOEA	2	2		
AGURID LARVAE	1	1		
	3,027	3,284		
RAB ALIQUOT				
Total BRACHYURAN ZOEA				
in 46% of sample	5	3		
CANCER MAGISTER	0	0		
CANCER spp.	1	1		

PLANKTON ANALYSIS

STATION 2 DATE February 3, 1971 COLLECTED BY L. Birke LAB NO. 270

TOW TYPE Surface TOW LENGTH 5 min ANALYZED BY R. Joslin

VOLUME SAMPLED (M^3) 3.5 CONCENTRATED VOLUME (ml) 185 ALIQUOT (ml) 20 PREDOMINANT ORGANISMS BARNACLE NAUPLII

NUMBER OF ORGANISMS/M^3 2157 NUMBER OF SPECIES 11 DIVERSITY INDEX 1.30

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ANNELIDS	8	21		
CALANOID COPEPODS	91	241		
CYCLOPOID COPEPODS	174	458		
HARPACTICOID COPEPODS	6	16		
COPEPOD NAUPLII	48	127		
BARNACLE NAUPLII	460	1,215		
CUMACEAN	2	5		
LARVACEANS (OIKOPLEURA)	16	42		
ECHINODERM LARVAE	4	11		
PELECYPOD LARVAE	6	16		
BRACHYURAN ZOEA	2	5		
	817	2,157		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA in 20% of sample	2	3		
CANCER MAGISTER	0	0		
CANCER spp.	0	0		

PLANKTON ANALYSIS

TION 2 DATE February 3, 1971 COLLECTED BY L. Birke LAB NO. 277

/ TYPE Surface TOW LENGTH 5 min ANALYZED BY A. Mahood

UME
PLED (M^3) 3.45 CONCENTRATED VOLUME (ml) 171 ALIQUOT (ml) 20 PREDOMINANT ORGANISMS COPEPODS

BER OF
ANISMS/M^3 860 NUMBER OF SPECIES 11 DIVERSITY INDEX 1.48

TIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ALANOID COPEPODS	84	210		
YCLOPOID COPEPODS	135	334		
ARPACTICOID COPEPODS	12	30		
OPEPOD NAUPLII	58	144		
ARNACLE NAUPLII	31	77		
HAETOGNATHS	14	35		
ARVACEANS (OIKOPLEURA)	9	22		
CHINODERM LARVAE	1	2		
ASTROPOD LARVAE	1	2		
ELECYPOD LARVAE	1	2		
RACHYURAN ZOEA	1	2		
	347	860		
RAB ALIQUOT				
Total BRACHYURAN ZOEA				
in 20% of sample	3	4		
CANCER MAGISTER	1	1		
CANCER spp.	2	3		

PLANKTON ANALYSIS

STATION 2 DATE February 3, 1971 COLLECTED BY L. Birke LAB NO 278

TOW TYPE 8 Meters TOW LENGTH 5 min ANALYZED BY A. Mahood

VOLUME SAMPLED (M^3) 1.2 CONCENTRATED VOLUME (ml) 186 ALIQUOT (ml) 20 PREDOMINANT ORGANISMS COPEPODS

NUMBER OF ORGANISMS/M^3 3139 NUMBER OF SPECIES 10 DIVERSITY INDEX 1.12

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
CALANOID COPEPODS	266	2,002		
CYCLOPOID COPEPODS	42	316		
HARPACTICOID COPEPODS	65	489		
COPEPOD NAUPLII	8	60		
BARNACLE NAUPLII	25	188		
BARNACLE CYPRIS	1	8		
CUMACEAN	2	15		
GASTROPOD LARVAE	1	8		
PELECYPOD LARVAE	3	23		
BRACHYURAN ZOEA	4	30		
	417	3,139		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA in 31% of sample	10	27		
CANCER MAGISTER	0	0		
CANCER spp.	0	0		

PLANKTON ANALYSIS

TION 2 DATE February 3, 1971 COLLECTED BY L. Birke LAB NO. 274

TYPE 8 Meter TOW LENGTH 5 min ANALYZED BY A. Mahood

UME PLED (M^3) 0.9 CONCENTRATED VOLUME (ml) 175 ALIQUOT (ml) 20 PREDOMINANT ORGANISMS COPEPODS

BER OF ANISMS/M^3 3714 NUMBER OF SPECIES 12 DIVERSITY INDEX 1.34

TIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
NNELIDS	11	104		
ALANOID COPEPODS	220	2,030		
YCLOPOID COPEPODS	65	607		
ARPACTICOID COPEPODS	51	477		
OPEPOD NAUPLII	32	300		
ARNACLE NAUPLII	8	75		
ARNACLE CYPRIS	2	19		
UPHASIDS	2	19		
ARVACEANS (OIKOPLEURA)	2	19		
CHINODERM LARVAE	1	9		
ELECYPOD LARVAE	1	9		
RACHYURAN ZOEA	5	46		
	400	3,714		
RAB ALIQUOT				
Total BRACHYURAN ZOEA				
in 31% of sample	19	68		
CANCER MAGISTER	0	0		
CANCER spp.	0	0		

PLANKTON ANALYSIS

STATION 3 DATE February 3, 1971 COLLECTED BY L. Birke LAB NO. 272

TOW TYPE Surface TOW LENGTH 5 min ANALYZED BY R. Joslin

VOLUME SAMPLED (M^3) 3.15 CONCENTRATED VOLUME (ml) 305 ALIQUOT (ml) 50 PREDOMINANT ORGANISMS COPEPODS

NUMBER OF ORGANISMS/M^3 151 NUMBER OF SPECIES 4 DIVERSITY INDEX 1.45

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
CALANOID COPEPODS	9	17		
CYCLOPOID COPEPODS	63	121		
COPEPOD NAUPLII	6	11		
BRACHYURAN ZOEA	1	2		
	79	151		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA in total sample	18	6		
CANCER MAGISTER	0	0		
CANCER spp.	13	3		

PLANKTON ANALYSIS

TION 3 DATE February 3, 1971 COLLECTED BY L. Birke LAB NO. 306

V TYPE Surface TOW LENGTH 5 min ANALYZED BY R. Joslin

UME MPLED (M^3) 3.1 CONCENTRATED VOLUME (ml) 32 ALIQUOT (ml) 3.2 PREDOMINANT ORGANISMS COPEPODS

MBER OF GANISMS/M^3 1755 NUMBER OF SPECIES 12 DIVERSITY INDEX 1.47

NTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
NNELIDS	1	3		
ALANOID COPEPODS	195	630		
YCLOPOID COPEPODS	176	568		
ARPACTICOID COPEPODS	10	32		
OPEPOD NAUPLII	73	236		
ARNACLE NAUPLII	66	213		
HAETOGNATHS	5	16		
ARVACEANS (OIKOPLEURA)	10	32		
CHINODERM LARVAE	1	3		
ASTROPOD LARVAE	5	16		
ELECYPOD LARVAE	1	3		
RACHYURAN ZOEA	1	3		
	544	1,755		
RAB ALIQUOT				
Total BRACHYURAN ZOEA in total sample	6	2		
CANCER MAGISTER	0	0		
CANCER spp.	0	0		

PLANKTON ANALYSIS

STATION 1 DATE February 8, 1971 COLLECTED BY L. Birke LAB NO. 269

TOW TYPE 8 Meters TOW LENGTH 5 min ANALYZED BY A. Mahood

VOLUME SAMPLED (M^3) 4.95 CONCENTRATED VOLUME (ml) 195 ALIQUOT (ml) 12 PREDOMINANT ORGANISMS COPEPODS

NUMBER OF ORGANISMS/M^3 1621 NUMBER OF SPECIES 10 DIVERSITY INDEX 1.22

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ANNELIDS	6	20		
CALANOID COPEPODS	101	336		
CYCLOPOID COPEPODS	167	561		
HARPACTICOID COPEPODS	95	319		
COPEPOD NAUPLII	17	57		
BARNACLE NAUPLII	70	235		
BARNACLE CYPRIS	7	23		
ISOPODA	1	3		
PELECYPOD LARVAE	16	54		
BRACHYURAN ZOEA	4	13		
	484	1,621		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA in total sample	188	38		
CANCER MAGISTER	0	0		
CANCER spp.	15	3		

PLANKTON ANALYSIS

ION 1 DATE February 8, 1971 COLLECTED BY L. Birke LAB NO. 244

TYPE Surface TOW LENGTH 5 min ANALYZED BY E. Wilson

UME PLED (M^3) 4.0 CONCENTRATED VOLUME (ml) 117 ALIQUOT (ml) 15 PREDOMINANT ORGANISMS COPEPODS

BER OF ANISMS/M^3 2449 NUMBER OF SPECIES 10 DIVERSITY INDEX 1.15

TIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
NNELIDS	10	19		
ALANOID COPEPODS	410	801		
YCLOPOID COPEPODS	528	1,031		
ARPACTICOID COPEPODS	25	49		
OPEPOD NAUPLII	115	222		
ARNACLE NAUPLII	47	92		
UMACEAN	1	2		
ARVACEANS (OIKOPLEURA)	98	191		
EDUSAE	10	19		
CHINODERM LARVAE	12	23		
	1,256	2,449		
RAB ALIQUOT				
Total BRACHYURAN ZOEA				
in 15/117 of sample	0	0		
CANCER MAGISTER	0	0		
CANCER spp.	0	0		

PLANKTON ANALYSIS

STATION 2 DATE February 8, 1971 COLLECTED BY L. Birke LAB NO. 242

TOW TYPE 8 Meters TOW LENGTH 5 min ANALYZED BY A. Mahood

VOLUME SAMPLED (M^3) 3.45 CONCENTRATED VOLUME (ml) 62 ALIQUOT (ml) 10 PREDOMINANT ORGANISMS COPEPODS

NUMBER OF ORGANISMS/M^3 2624 NUMBER OF SPECIES 11 DIVERSITY INDEX 1.27

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ANNELIDS	7	13		
CALANOID COPEPODS	449	807		
CYCLOPOID COPEPODS	303	544		
HARPACTICOID COPEPODS	413	742		
COPEPOD NAUPLII	42	76		
BARNACLE NAUPLII	195	350		
BARNACLE CYPRIS	7	13		
BRACHYURAN ZOEA	19	34		
ISOPOD	3	5		
LARVACEANS (OIKOPLEURA)	16	29		
PELECYPOD LARVAE	6	11		
	1,460	2,624		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA in 10/62 of sample	19	34		
CANCER MAGISTER	0	0		
CANCER spp.	0	0		

PLANKTON ANALYSIS

ION 3 DATE February 8, 1971 COLLECTED BY L. Birke LAB NO. 249

TYPE 8 Meters TOW LENGTH 5 min ANALYZED BY A. Mahood

ME PLED (M^3) 1.75 CONCENTRATED VOLUME (ml) 86 ALIQUOT (ml) 10 PREDOMINANT ORGANISMS COPEPODS

BER OF ANISMS/M^3 2663 NUMBER OF SPECIES 13 DIVERSITY INDEX 1.52

TIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
NELIDS	76	373		
LANOID COPEPODS	142	697		
CLOPOID COPEPODS	166	816		
RPACTICOID COPEPODS	60	295		
PEPOD NAUPLII	46	226		
RNACLE NAUPLII	11	54		
RNACLE CYPRIS	10	49		
PHAUSIDS	1	5		
RVACEANS (OIKOPLEURA)	5	25		
AETOGNATHS	1	5		
STROPOD LARVAE	2	10		
LECYPOD LARVAE	14	69		
RACHYURAN ZOEA	8	39		
	542	2,663		
AB ALIQUOT				
Total BRACHYURAN ZOEA				
in 10/86 of sample	8	39		
CANCER MAGISTER	0	0		
CANCER spp.	0	0		

PLANKTON ANALYSIS

STATION 4 DATE February 8, 1971 COLLECTED BY L. Birke LAB NO. 241

TOW TYPE Surface TOW LENGTH 5 min ANALYZED BY R. Joslin

VOLUME SAMPLED (M^3) 3.25 CONCENTRATED VOLUME (ml) 90 ALIQUOT (ml) 10 PREDOMINANT ORGANISMS COPEPODS

NUMBER OF ORGANISMS/M^3 556 NUMBER OF SPECIES 8 DIVERSITY INDEX 1.11

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ANNELIDS	7	19		
CALANOID COPEPODS	80	221		
CYCLOPOID COPEPODS	53	146		
HARPACTICOID COPEPODS	17	47		
COPEPOD NAUPLII	36	100		
BARNACLE NAUPLII	2	6		
LARVACEANS (OIKOPLEURA)	5	14		
BRACHYURAN ZOEA	1	3		
	201	556		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA in 30/90 of sample	1	1		
CANCER MAGISTER	0	0		
CANCER spp.	0	0		

PLANKTON ANALYSIS

ON 4 DATE February 8, 1971 COLLECTED BY L. Birke LAB NO. 240

YPE 8 Meters TOW LENGTH 5 min ANALYZED BY A. Mahood

ME LED (M^3) 3.05 CONCENTRATED VOLUME (ml) 198 ALIQUOT (ml) 20 PREDOMINANT ORGANISMS COPEPODS

ER OF NISMS/M^3 4551 NUMBER OF SPECIES 8 DIVERSITY INDEX 0.83

FICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
NELIDS	11	36		
LANOID COPEPODS	662	2,149		
CLOPOID COPEPODS	388	1,259		
RPACTICOID COPEPODS	97	315		
PEPOD NAUPLII	68	221		
RNACLE NAUPLII	120	390		
RVACEANS (OIKOPLEURA)	46	149		
ACHYURAN ZOEA	10	32		
	1,402	4,551		
AB ALIQUOT				
Total BRACHYURAN ZOEA				
in 70/198 of sample	15	14		
CANCER MAGISTER	0	0		
CANCER spp.	2	2		

PLANKTON ANALYSIS

STATION 5 DATE February 8, 1971 COLLECTED BY L. Birke LAB NO. 267

TOW TYPE Surface TOW LENGTH 5 min ANALYZED BY A. Mahood

VOLUME SAMPLED (M^3) 3.6 CONCENTRATED VOLUME (ml) 125 ALIQUOT (ml) 15 PREDOMINANT ORGANISMS COPEPODS

NUMBER OF ORGANISMS/M^3 505 NUMBER OF SPECIES 9 DIVERSITY INDEX 1.28

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ANNELIDS	8	19		
CALANOID COPEPODS	72	167		
CYCLOPOID COPEPODS	75	173		
HARPACTICOID COPEPODS	5	12		
COPEPOD NAUPLII	31	72		
BARNACLE NAUPLII	4	9		
EUPHAUSID	1	2		
LARVACEANS (OIKOPLEURA)	20	46		
BRACHYURAN ZOEA	2	5		
	218	505		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA in 45/125 of sample	2	2		
CANCER MAGISTER	0	0		
CANCER spp.	0	0		

PLANKTON ANALYSIS

ON 5 DATE February 8, 1971 COLLECTED BY L. Birke LAB NO. 202

YPE Surface TOW LENGTH 5 min ANALYZED BY R. Joslin

ME
LED (M^3) 2.95 CONCENTRATED VOLUME (ml) 194 ALIQUOT (ml) 20 PREDOMINANT ORGANISMS COPEPODS

ER OF
NISMS/M^3 1006 NUMBER OF SPECIES 8 DIVERSITY INDEX 1.01

FICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
NELIDS	2	7		
LANOID COPEPODS	80	262		
CLOPOID COPEPODS	120	394		
RPACTICOID COPEPODS	4	13		
PEPOD NAUPLII	65	214		
RNACLE NAUPLII	3	10		
AETOGNATHS	2	7		
RVACEANS (OIKOPLEURA)	30	99		
	306	1,006		
AB ALIQUOT				
Total BRACHYURAN ZOEA				
in 60/194 of sample	0	0		
CANCER MAGISTER	0	0		
CANCER spp.	0	0		

PLANKTON ANALYSIS

STATION 5 DATE February 8, 1971 COLLECTED BY L. Birke LAB NO. 201

TOW TYPE 8 Meters TOW LENGTH 5 min ANALYZED BY R. Joslin

VOLUME SAMPLED (M^3) 2.45 CONCENTRATED VOLUME (ml) 134 ALIQUOT (ml) 15 PREDOMINANT ORGANISMS COPEPODS

NUMBER OF ORGANISMS/M^3 3183 NUMBER OF SPECIES 12 DIVERSITY INDEX 1.36

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ANNELIDS	1	4		
CALANOID COPEPODS	115	419		
CYCLOPOID COPEPODS	331	1,206		
HARPACTICOID COPEPODS	25	91		
COPEPOD NAUPLII	35	128		
BARNACLE NAUPLII	114	416		
BARNACLE LARVAE	4	15		
CHAETOGNATHS	2	7		
LARVACEANS (OIKOPLEURA)	120	438		
GASTROPOD LARVAE	5	18		
PELECYPOD LARVAE	107	390		
BRACHYURAN ZOEA	14	51		
	873	3,183		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA in 30/134 of sample	20	36		
CANCER MAGISTER	0	0		
CANCER spp.	1	2		

PLANKTON ANALYSIS

ON 6 DATE February 8, 1971 COLLECTED BY L. Pirtle LAB NO. 203

TYPE Surface TOW LENGTH 5 min ANALYZED BY R. Joslin

ME LED (M^3) 3.35 CONCENTRATED VOLUME (ml) 90 ALIQUOT (ml) 20 PREDOMINANT ORGANISMS COPEPODS

ER OF NISMS/M^3 2411 NUMBER OF SPECIES 13 DIVERSITY INDEX 1.54

FICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
NELIDS	16	21		
LANOID COPEPODS	692	929		
CLOPOID COPEPODS	488	656		
RPACTICOID COPEPODS	82	110		
PEPOD NAUPLII	160	215		
RNACLE NAUPLII	101	136		
RNACLE CYPRIS	1	1		
AETOGNATHS	2	3		
RVACEANS (OIKOPLEURA)	195	262		
STROPOD LARVAE	1	1		
ECYPOD LARVAE	57	77		
	1,795	2,411		
AB ALIQUOT				
Total BRACHYURAN ZOEA				
in 40/90 of sample	1	1		
CANCER MAGISTER	0	0		
CANCER spp.	1	1		

PLANKTON ANALYSIS

STATION 6 DATE February 8, 1971 COLLECTED BY L. Birke LAB NO. 243

TOW TYPE 8 Meters TOW LENGTH 5 min ANALYZED BY R. Joslin

VOLUME SAMPLED (M^3) 2.1 CONCENTRATED VOLUME (ml) 250 ALIQUOT (ml) 30 PREDOMINANT ORGANISMS COPEPODS

NUMBER OF ORGANISMS/M^3 1230 NUMBER OF SPECIES 10 DIVERSITY INDEX 1.39

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ANNELIDS	33	131		
CALANOID COPEPODS	97	385		
HARPACTICOID COPEPODS	21	83		
CYCLOPOID COPEPODS	117	464		
COPEPOD NAUPLII	20	79		
BARNACLE NAUPLII	1	4		
BARNACLE CYPRIS	1	4		
EUPHAUSIDS	1	4		
PELECYPOD LARVAE	9	36		
GASTROPOD LARVAE	10	40		
	310	1,230		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA in 80/250 of sample	2	3		
CANCER MAGISTER	0	0		
CANCER spp.	0	0		

PLANKTON ANALYSIS

ON 1 DATE March 1, 1971 COLLECTED BY L. Birke LAB NO. 207

TYPE Surface TOW LENGTH 3 min ANALYZED BY R. Joslin

ME PLED (M^3) 0.7 CONCENTRATED VOLUME (ml) 200 ALIQUOT (ml) 25 PREDOMINANT ORGANISMS COPEPODS

BER OF ANISMS/M^3 6400 NUMBER OF SPECIES 10 DIVERSITY INDEX 1.03

IFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
NELIDS	24	274		
LANOID COPEPODS	377	4,310		
CLOPOID COPEPODS	37	423		
RPACTICOID COPEPODS	15	171		
PEPOD NAUPLII	81	926		
RNACLE NAUPLII	5	57		
RVACEANS (OIKOPLEURA)	3	34		
STROPOD LARVAE	1	11		
LECYPOD LARVAE	2	23		
ACHYURAN ZOEA	15	171		
	560	6,400		
AB ALIQUOT				
Total BRACHYURAN ZOEA				
in 25/200 of sample	15	8		
CANCER MAGISTER	0	0		
CANCER spp.	1	11		

PLANKTON ANALYSIS

STATION 1 DATE March 1, 1971 COLLECTED BY L. Birke LAB NO. 206

TOW TYPE 8 Meters TOW LENGTH 5 min ANALYZED BY A. Mahood

VOLUME SAMPLED (M^3) 2.4 CONCENTRATED VOLUME (ml) 330 ALIQUOT (ml) 40 PREDOMINANT ORGANISMS COPEPODS

NUMBER OF ORGANISMS/M^3 835 NUMBER OF SPECIES 10 DIVERSITY INDEX 1.34

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ANNELIDS	2	7		
CALANOID COPEPODS	130	448		
CYCLOPOID COPEPODS	14	48		
HARPACTICOID COPEPODS	51	175		
COPEPOD NAUPLII	20	69		
BARNACLE NAUPLII	11	38		
BARNACLE CYPRIS	1	3		
ISOPODA	3	10		
LARVACEANS (OIKOPLEURA)	1	3		
BRACHYURAN ZOEA	10	34		
	243	835		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA in 40/330 of sample	10	34		
CANCER MAGISTER	0	0		
CANCER spp.	0	0		

PLANKTON ANALYSIS

ION 2 DATE March 1, 1971 COLLECTED BY L. Birke LAB NO. 204

TYPE Surface TOW LENGTH 4 min ANALYZED BY R. Joslin

UME PLED (M^3) 1.0 CONCENTRATED VOLUME (ml) 270 ALIQUOT (ml) 30 PREDOMINANT ORGANISMS COPEPOD NAUPLII

BER OF ANISMS/M^3 207 NUMBER OF SPECIES 6 DIVERSITY INDEX 0.94

TIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
LANOID COPEPODS	1	9		
CLOPOID COPEPODS	6	54		
RPACTICOID COPEPODS	1	9		
PEPOD NAUPLII	11	99		
AETOGNATHS	1	9		
RVACEANS	3	27		
	23	207		
AB ALIQUOT				
Total BRACHYURAN LARVAE				
in 60/270 of sample	0			
CANCER MAGISTER	0			
CANCER spp.	0			

PLANKTON ANALYSIS

STATION 2 DATE March 1, 1971 COLLECTED BY L. Birke LAB NO. 210

TOW TYPE 8 Meters TOW LENGTH 5 min ANALYZED BY R. Joslin

VOLUME SAMPLED (M^3) 4.6 CONCENTRATED VOLUME (ml) 156 ALIQUOT (ml) 25 PREDOMINANT ORGANISMS None

NUMBER OF ORGANISMS/M^3 None NUMBER OF SPECIES None DIVERSITY INDEX None

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
Nothing in ALIQUOT but a little debris.			Possible decomposition of sample. Plankton meter may have malfunctioned.	

PLANKTON ANALYSIS

TION 3 DATE March 1, 1971 COLLECTED BY L. Birke LAB NO. 213

V TYPE Surface TOW LENGTH 5 min ANALYZED BY A. Mahood

LUME MPLED (M^3) 1.35 CONCENTRATED VOLUME (ml) 216 ALIQUOT (ml) 40 PREDOMINANT ORGANISMS COPEPODS

MBER OF GANISMS/M^3 324 NUMBER OF SPECIES 7 DIVERSITY INDEX 1.25

NTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
NNELIDS	1	4		
CALANOID COPEPODS	37	148		
CYCLOPOID COPEPODS	7	28		
HARPACTICOID COPEPODS	2	8		
COPEPOD NAUPLII	30	120		
BARNACLE NAUPLII	1	4		
LARVACEANS	3	12		
	81	324		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA				
in 20/216 of sample	0	0		
CANCER MAGISTER	0			
CANCER spp.	0			

PLANKTON ANALYSIS

STATION 3 DATE March 1, 1971 COLLECTED BY L. Birke LAB NO. 211

TOW TYPE 8 Meters TOW LENGTH 5 min ANALYZED BY A. Mahood

VOLUME SAMPLED (M^3) 2.1 CONCENTRATED VOLUME (ml) 192 ALIQUOT (ml) 25 PREDOMINANT ORGANISMS COPEPODS

NUMBER OF ORGANISMS/M^3 249 NUMBER OF SPECIES 8 DIVERSITY INDEX 1.28

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ANNELIDS	6	22		
CALANOID COPEPODS	23	84		
CYCLOPOID COPEPODS	13	48		
HARPACTICOID COPEPODS	4	15		
COPEPOD NAUPLII	14	51		
BARNACLE NAUPLII	2	7		
LARVACEANS	4	15		
BRACHYURAN ZOEA	2	7		
	68	249		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA in 50/192 of sample	2	4		
CANCER MAGISTER	0	0		
CANCER spp.	0	0		

PLANKTON ANALYSIS

ATION 4 DATE March 1, 1971 COLLECTED BY L. Birke LAB NO. 209

W TYPE Surface TOW LENGTH 5 min ANALYZED BY R. Joslin

LUME MPLED (M^3) 2.15 CONCENTRATED VOLUME (ml) 190 ALIQUOT (ml) 25 PREDOMINANT ORGANISMS COPEPODS

MBER OF GANISMS/M^3 2556 NUMBER OF SPECIES 12 DIVERSITY INDEX 1.40

NTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ANNELIDS	72	255		
CALANOID COPEPODS	488	1,724		
CYCLOPOID COPEPODS	26	92		
HARPACTICOID COPEPODS	14	49		
COPEPOD NAUPLII	81	286		
BARNACLE NAUPLII	32	113		
BARNACLE CYPRIS	1	4		
CUMACEAN	2	7		
EUPHAUSIDS	4	14		
CLADOCERAN	1	4		
CHAETOGNATHS	1	4		
PELECYPOD LARVAE	1	4		
	723	2,556		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA				
in 50/190 of sample	0	0		
CANCER MAGISTER	0	0		
CANCER spp..	0	0		

PLANKTON ANALYSIS

STATION 4 DATE March 1, 1971 COLLECTED BY L. Birke LAB NO. 214

TOW TYPE 8 Meters TOW LENGTH 5 min ANALYZED BY A. Mahood

VOLUME SAMPLED (M^3) 2.4 CONCENTRATED VOLUME (ml) 182 ALIQUOT (ml) 25 PREDOMINANT ORGANISMS COPEPODS

NUMBER OF ORGANISMS/M^3 476 NUMBER OF SPECIES 9 DIVERSITY INDEX 1.30

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ANNELIDS	27	82		
CALANOID COPEPODS	64	195		
CYCLOPOID COPEPODS	15	45		
HARPACTICOID COPEPODS	6	18		
COPEPOD NAUPLII	35	106		
BARNACLE NAUPLII	5	15		
LARVACEANS (OIKOPLEURA)	2	6		
BRACHYURAN ZOEA	2	6		
PORCELLANID ZOEA	1	3		
	157	476		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA in 25/182 of sample	2	6		
CANCER MAGISTER	0	0		
CANCER spp.	0	0		

PLANKTON ANALYSIS

ATION 5 DATE March 1, 1971 COLLECTED BY L. Birke LAB NO. 205

W TYPE Surface TOW LENGTH 5 min ANALYZED BY R. Joslin

LUME MPLED (M^3) 3.2 CONCENTRATED VOLUME (ml) 190 ALIQUOT (ml) 25 PREDOMINANT ORGANISMS COPEPODS

MBER OF GANISMS/M^3 408 NUMBER OF SPECIES 10 DIVERSITY INDEX 1.50

NTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ANNELIDS	1	2		
CALANOID COPEPODS	106	253		
CYCLOPOID COPEPODS	22	52		
HARPACTICOID COPEPODS	3	7		
COPEPOD NAUPLII	25	59		
BARNACLE NAUPLII	9	21		
BARNACLE CYPRIS	1	2		
LARVACEANS (OIKOPLEURA)	2	5		
ECHINODERM LARVAE	1	2		
GASTROPOD LARVAE	2	5		
	172	408		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA				
in 50/190 of sample	0	0		
CANCER MAGISTER	0	0		
CANCER spp.	0	0		

PLANKTON ANALYSIS

STATION 5 DATE March 1, 1971 COLLECTED BY L. Birke LAB NO. 212

TOW TYPE 8 Meters TOW LENGTH 5 min ANALYZED BY J. Carson

VOLUME SAMPLED (M^3) 1.3 CONCENTRATED VOLUME (ml) 175 ALIQUOT (ml) 20 PREDOMINANT ORGANISMS COPEPODS

NUMBER OF ORGANISMS/M^3 639 NUMBER OF SPECIES 8 DIVERSITY INDEX 1.08

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ANNELIDS	32	215		
CALANOID COPEPODS	33	222		
CYCLOPOID COPEPODS	17	114		
COPEPOD NAUPLII	5	34		
BARNACLE NAUPLII	3	20		
CHAETOGNATHS	1	7		
ECHINODERM LARVAE	1	7		
BRACHYURAN ZOEA	3	20		
.	95	639		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA				
in 45/175 of sample	3	9		
CANCER MAGISTER	0	0		
CANCER spp.	0	0		

PLANKTON ANALYSIS

ATION 6 DATE March 1, 1971 COLLECTED BY L. Birke LAB NO. 208

W TYPE Surface TOW LENGTH 5 min ANALYZED BY A. Mahood

LUME MPLED (M^3) 3.7 CONCENTRATED VOLUME (ml) 112 ALIQUOT (ml) 20 PREDOMINANT ORGANISMS COPEPODS

MBER OF GANISMS/M^3 389 NUMBER OF SPECIES 7 DIVERSITY INDEX 1.01

ENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ANNELIDS	17	26		
CALANOID COPEPODS	100	150		
CYCLOPOID COPEPODS	44	67		
HARPACTICOID COPEPODS	50	76		
COPEPODS NAUPLII	37	56		
BARNACLE NAUPLII	6	9		
LARVACEANS (OIKOPLEURA)	3	5		
	257	389		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA				
in 45/112 of sample	0	0		
CANCER MAGISTER	0	0		
CANCER spp.	0	0		

PLANKTON ANALYSIS

STATION 6 DATE March 1, 1971 COLLECTED BY L. Birke LAB NO. 305

TOW TYPE 8 Meters TOW LENGTH 5 min ANALYZED BY E. Wilson

VOLUME SAMPLED (M^3) 2.65 CONCENTRATED VOLUME (ml) 360 ALIQUOT (ml) 30 PREDOMINANT ORGANISMS COPEPODS

NUMBER OF ORGANISMS/M^3 6076 NUMBER OF SPECIES 11 DIVERSITY INDEX 1.15

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ANNELIDS	400	1,811		
CALANOID COPEPODS	630	2,854		
CYCLOPOID COPEPODS	57	258		
HARPACTICOID COPEPODS	40	181		
COPEPOD NAUPLII	69	312		
BARNACLE NAUPLII	29	131		
CUMACEANS	2	9		
LARVACEANS (OIKOPLEURA)	6	27		
GASTROPOD LARVAE	23	104		
PELECYPOD LARVAE	86	389		
	1,342	6,076		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA in 60/360 of sample	11	25		
CANCER MAGISTER	0	0		
CANCER spp.	3	7		

PLANKTON ANALYSIS

ATION 1 DATE March 29, 1971 COLLECTED BY G. Bailey LAB NO. 235

W TYPE Surface TOW LENGTH 5 min ANALYZED BY R. Joslin

LUME MPLED (M^3) 1.15 CONCENTRATED VOLUME (ml) 220 ALIQUOT (ml) 30 PREDOMINANT ORGANISMS COPEPODS

MBER OF GANISMS/M^3 6932 NUMBER OF SPECIES 8 DIVERSITY INDEX 0.79

NTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ANNELIDS	6	38		
CALANOID COPEPODS	546	3,483		
CYCLOPOID COPEPODS	51	325		
COPEPOD NAUPLII	232	1,479		
EUPHAUSIDS	10	64		
BARNACLE NAUPLII	204	1,301		
LARVACEANS	35	223		
ECHINODERM LARVAE	3	19		
	1,087	6,932		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA				
in 80/220 of sample	0	0		
CANCER MAGISTER	0	0		
CANCER spp.	0	0		

PLANKTON ANALYSIS

STATION 1 DATE March 29, 1971 COLLECTED BY G. Bailey LAB NO. 229

TOW TYPE Surface TOW LENGTH 5 min ANALYZED BY R. Joslin

VOLUME SAMPLED (M^3) 1.15 CONCENTRATED VOLUME (ml) 226 ALIQUOT (ml) 30 PREDOMINANT ORGANISMS COPEPODS

NUMBER OF ORGANISMS/M^3 1729 NUMBER OF SPECIES 7 DIVERSITY INDEX 0.80

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ANNELIDS	1	7		
CALANOID COPEPODS	161	1,054		
CYCLOPOID COPEPODS	3	20		
COPEPOD NAUPLII	60	392		
BARNACLE NAUPLII	1	7		
LARVACEANS	35	229		
ECHINODERM LARVAE	3	20		
	264	1,729		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA in 80/226 of sample	0	0		
CANCER MAGISTER	0	0		
CANCER spp.	0	0		

PLANKTON ANALYSIS

ATION 1 DATE March 29, 1971 COLLECTED BY G. Bailey LAB NO. 237

W TYPE 8 Meters TOW LENGTH 5 min ANALYZED BY E. Wilson

LUME MPLED (M^3) 1.15 CONCENTRATED VOLUME (ml) 220 ALIQUOT (ml) 30 PREDOMINANT ORGANISMS COPEPODS

MBER OF GANISMS/M^3 11,331 NUMBER OF SPECIES 11 DIVERSITY INDEX 0.96

NTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ANNELIDS	106	676		
CALANOID COPEPODS	655	4,176		
CYCLOPOID COPEPODS	102	650		
HARPACTICOID COPEPODS	4	26		
COPEPOD NAUPLII	439	2,799		
BARNACLE NAUPLII	315	2,009		
BARNACLE CYPRIS	17	108		
CUMACEAN	4	26		
GASTROPOD LARVAE	8	51		
LARVACEANS	119	759		
BRACHYURAN ZOEA	8	51		
	1,777	11,331		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA				
in 30/220 of sample	8	51		
CANCER MAGISTER	0	0		
CANCER spp.	0	0		

PLANKTON ANALYSIS

STATION 1 DATE March 29, 1971 COLLECTED BY G. Bailey LAB NO. 239

TOW TYPE 8 Meters TOW LENGTH 5 min ANALYZED BY A. Mahood

VOLUME SAMPLED (M^3) 1.6 CONCENTRATED VOLUME (ml) 380 ALIQUOT (ml) 40 PREDOMINANT ORGANISMS COPEPODS

NUMBER OF ORGANISMS/M^3 6460 NUMBER OF SPECIES 11 DIVERSITY INDEX 1.14

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ANNELIDS	31	184		
CALANOID COPEPODS	383	2,274		
CYCLOPOID COPEPODS	47	279		
HARPACTICOID COPEPODS	4	24		
COPEPOD NAUPLII	451	2,677		
BARNACLE NAUPLII	121	718		
BARNACLE CYPRIS	35	208		
EUPHAUSIDS	4	24		
CUMACEANS	2	12		
LARVACEANS	2	12		
BRACHYURAN ZOEA	8	48		
	1,088	6,460		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA in 40/380 of sample	9	53		
CANCER MAGISTER	0	0		
CANCER spp.	1	3		

PLANKTON ANALYSIS

ATION 2 DATE March 29, 1971 COLLECTED BY G. Bailey LAB NO. 228

W TYPE Surface TOW LENGTH 5 min ANALYZED BY R. Joslin

LUME MPLED (M^3) 0.7 CONCENTRATED VOLUME (ml) 218 ALIQUOT (ml) 30 PREDOMINANT ORGANISMS COPEPODS

MBER OF GANISMS/M^3 6875 NUMBER OF SPECIES 8 DIVERSITY INDEX 0.79

NTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
CALANOID COPEPODS	363	3,769		
CYCLOPOID COPEPODS	12	125		
HARPACTICOID COPEPODS	4	42		
COPEPOD JUVENILES	93	965		
COPEPOD NAUPLII	117	1,215		
BARNACLCE NAUPLII	65	675		
BARNACLCE CYPRIS	4	42		
ISOPODA	4	42		
	662	6,875		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA				
in 30/218 of sample	0	0		
CANCER MAGISTER	0	0		
CANCER spp.	0	0		

PLANKTON ANALYSIS

STATION 2 DATE March 29, 1971 COLLECTED BY G. Bailey LAB NO. 236

TOW TYPE 8 Meters TOW LENGTH 5 min ANALYZED BY A. Mahood

VOLUME SAMPLED (M^3) 1.3 CONCENTRATED VOLUME (ml) 227 ALIQUOT (ml) 30 PREDOMINANT ORGANISMS COPEPODS

NUMBER OF ORGANISMS/M^3 3102 NUMBER OF SPECIES 11 DIVERSITY INDEX 1.24

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
HYDROMEDUSAE	2 in total sample	2		
ANNELIDA	14	81		
CALANOID COPEPODS	189	1,100		
CYCLOPOID COPEPODS	25	146		
HARPACTICOID COPEPODS	3	17		
COPEPOD LARVAE	255	1,484		
BARNACLE NAUPLII	20	116		
BARNACLE CYPRIS	3	17		
ISOPODA	3	17		
LARVACEANS	20	116		
BRACHYURAN ZOEA	1	6		
	533	3,102		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA in 30/227 of sample	1	6		
CANCER MAGISTER	0	0		
CANCER spp.	0	0		

PLANKTON ANALYSIS

ATION 5 DATE March 29, 1971 COLLECTED BY G. Bailey LAB NO. 230

W TYPE Surface TOW LENGTH 5 min ANALYZED BY R. Joslin

LUME MPLED (M^3) 0.35 CONCENTRATED VOLUME (ml) 244 ALIQUOT (ml) 30 PREDOMINANT ORGANISMS COPEPODS

MBER OF GANISMS/M^3 11,061 NUMBER OF SPECIES 9 DIVERSITY INDEX 0.86

NTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ANNELIDS	10	232		
CALANOID COPEPODS	180	4,184		
CYCLOPOID COPEPODS	50	1,162		
COPEPOD NAUPLII	85	1,975		
BARNACLE NAUPLII	123	2,858		
BARNACLE CYPRIS	5	116		
OSTRACOD	1	23		
LARVACEANS	17	395		
BRACHYURAN ZOEA	5	116		
	476	11,061		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA				
in 30/244 of sample	5	116		
CANCER MAGISTER	0	0		
CANCER spp.	2	56		

PLANKTON ANALYSIS

STATION 5 DATE March 29, 1971 COLLECTED BY G. Bailey LAB NO. 233

TOW TYPE 8 Meters TOW LENGTH 5 min ANALYZED BY A. Mahood

VOLUME SAMPLED (M^3) 0.6 CONCENTRATED VOLUME (ml) 270 ALIQUOT (ml) 50 PREDOMINANT ORGANISMS COPEPODS

NUMBER OF ORGANISMS/M^3 3447 NUMBER OF SPECIES 11 DIVERSITY INDEX 1.23

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ANNELIDS	30	270		
CALANOID COPEPODS	157	1,413		
CYCLOPOID COPEPODS	22	198		
HARPACTICOID COPEPODS	2	18		
COPEPOD JUVENILES	30	270		
COPEPOD NAUPLII	62	558		
EUPHAUSIDS	2	18		
BARNACLE NAUPLII	38	342		
BARNACLE CYPRIS	6	54		
ISOPODA	1	9		
LARVACEANS	30	270		
BRACHYURAN ZOEA	3	27		
	383	3,447		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA in 50/270 of sample	3	27		
CANCER MAGISTER	0	0		
CANCER spp.	0	0		

PLANKTON ANALYSIS

ATION 6 DATE March 29, 1971 COLLECTED BY G. Bailey LAB NO. 234

W TYPE Surface TOW LENGTH 5 min ANALYZED BY A. Mahood

OLUME AMPLED (M^3) 2.2 CONCENTRATED VOLUME (ml) 310 ALIQUOT (ml) 30 PREDOMINANT ORGANISMS COPEPOD NAUPLII

UMBER OF RGANISMS/M^3 4151 NUMBER OF SPECIES 7 DIVERSITY INDEX 0.84

ENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ANNELIDS	12	56		
CALANOID COPEPODS	226	1,061		
CYCLOPOID COPEPODS	43	202		
COPEPOD NAUPLII	540	2,537		
BARNACLE NAUPLII	5	23		
BARNACLE CYPRIS	2	9		
LARVACEANS	56	263		
	884	4,151		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA in 30/310 of sample	0	0		
CANCER MAGISTER	0	0		
CANCER spp.	0	0		

PLANKTON ANALYSIS

STATION 6 DATE March 29, 1971 COLLECTED BY G. Bailey LAB NO. 232

TOW TYPE Surface TOW LENGTH 5 min ANALYZED BY R. Joslin

VOLUME SAMPLED (M^3) 1.8 CONCENTRATED VOLUME (ml) 226 ALIQUOT (ml) 30 PREDOMINANT ORGANISMS COPEPODS

NUMBER OF ORGANISMS/M^3 4097 NUMBER OF SPECIES 7 DIVERSITY INDEX 0.84

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
CALANOID COPEPODS	545	2,282		
CYCLOPOID COPEPODS	35	146		
COPEPOD NAUPLII	375	1,569		
EUPHAUSIDS	5	21		
BARNACLE NAUPLII	5	21		
LARVACEANS	12	50		
PELECYPOD LARVAE	2	8		
	979	4,097		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA in 70/226 of sample	0	0		
CANCER MAGISTER	0	0		
CANCER spp.	0	0		

PLANKTON ANALYSIS

ATION 6 DATE March 29, 1971 COLLECTED BY G. Bailey LAB NO. 238

W TYPE 8 Meters TOW LENGTH 5 min ANALYZED BY R. Joslin

LUME MPLED (M^3) 0.65 CONCENTRATED VOLUME (ml) 310 ALIQUOT (ml) 30 PREDOMINANT ORGANISMS COPEPOD NAUPLII

MBER OF GANISMS/M^3 20,316 NUMBER OF SPECIES 12 DIVERSITY INDEX 1.11

NTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ANNELIDS	40	636		
CALANOID COPEPODS	388	6,168		
CYCLOPOID COPEPODS	62	986		
HARPACTICOID COPEPODS	4	64		
COPEPOD NAUPLII	564	8,965		
EUPHAUSIDS	1	16		
BARNACLE NAUPLII	184	2,924		
BARNACLE CYPRIS	18	286		
CUMACEANS	1	16		
LARVACEANS	13	207		
GASTROPOD LARVAE	1	16		
BRACHYURAN ZOEA	2	32		
	1,278	20,316		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA in 30/310 of sample	2	32		
CANCER MAGISTER	0	0		
CANCER spp.	1	16		

PLANKTON ANALYSIS

STATION 6 DATE March 29, 1971 COLLECTED BY G. Bailey LAB NO. 231

TOW TYPE 8 Meters TOW LENGTH 5 min ANALYZED BY A. Mahood

VOLUME SAMPLED (M^3) 1.05 CONCENTRATED VOLUME (ml) 292 ALIQUOT (ml) 30 PREDOMINANT ORGANISMS COPEPOD NAUPLII

NUMBER OF ORGANISMS/M^3 1390 NUMBER OF SPECIES 9 DIVERSITY INDEX 1.11

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ANNELIDS	4	37		
CALANOID COPEPODS	8	74		
CYCLOPOID COPEPODS	2	19		
HARPACTICOID COPEPODS	3	28		
COPEPOD JUVENILES	5	46		
COPEPOD NAUPLII	55	510		
BARNACLE NAUPLII	59	546		
BARNACLE CYPRIS	7	65		
LARVACEANS	1	9		
BRACHYURAN ZOEA	6	56		
	150	1,390		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA in 30/292 of sample	6	56		
CANCER MAGISTER	0	0		
CANCER spp.	1	9		

PLANKTON ANALYSIS

STATION 1 DATE April 14, 1971 COLLECTED BY G. Bailey LAB NO. 225

TOW TYPE Surface TOW LENGTH 5 min ANALYZED BY E. Wilson

VOLUME SAMPLED (M^3) 1.55 CONCENTRATED VOLUME (ml) 276 ALIQUOT (ml) 30 PREDOMINANT ORGANISMS COPEPODS

NUMBER OF ORGANISMS/M^3 2879 NUMBER OF SPECIES 13 DIVERSITY INDEX 1.51

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ANNELIDS	15	89		
CALANOID COPEPODS	121	718		
CYCLOPOID COPEPODS	34	202		
HARPACTICOID COPEPODS	3	18		
COPEPOD NAUPLII	79	469		
BARNACLE NAUPLII	135	801		
BARNACLE CYPRIS	2	12		
ISOPODA	1	6		
EUPHAUSIDS	1	6		
CUMACEANS	1	6		
LARVACEANS (OIKOPLEURA)	90	534		
MEDUSAE	2	12		
BRACHYURAN ZOEA	1	6		
	485	2,879		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA in 30/276 of sample	1	6		
CANCER MAGISTER	0	0		
CANCER spp.	0	0		

PLANKTON ANALYSIS

STATION 1 DATE April 14, 1971 COLLECTED BY G. Bailey LAB NO. 221

TOW TYPE Surface TOW LENGTH 5 min ANALYZED BY R. Joslin

VOLUME SAMPLED (M^3) 1.05 CONCENTRATED VOLUME (ml) 316 ALIQUOT (ml) 20 PREDOMINANT ORGANISMS COPEPODS

NUMBER OF ORGANISMS/M^3 5026 NUMBER OF SPECIES 12 DIVERSITY INDEX 0.98

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ANNELIDS	2	30		
CALANOID COPEPODS	116	1,746		
CYCLOPOID COPEPODS	21	316		
HARPACTICOID COPEPODS	3	45		
COPEPOD NAUPLII	84	1,264		
BARNACLE NAUPLII	47	707		
BARNACLE CYPRIS	1	15		
ISOPODA	1	15		
EUPHAUSIDS	5	75		
LARVACEANS (OIKOPLEURA)	53	798		
BRACHYURAN ZOEA	1	15		
	334	5,026		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA in 70/316 of sample	1	5		
CANCER MAGISTER	0	0		
CANCER spp.	0	0		

PLANKTON ANALYSIS

ATION 1 DATE April 14, 1971 COLLECTED BY G. Bailey LAB NO. 223

W TYPE 8 Meters TOW LENGTH 5 min ANALYZED BY A. Mahood

OLUME AMPLED (M^3) 2.9 CONCENTRATED VOLUME (ml) 274 ALIQUOT (ml) 20 PREDOMINANT ORGANISMS COPEPODS

UMBER OF RGANISMS/M^3 2480 NUMBER OF SPECIES 9 DIVERSITY INDEX 1.02

ENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ANNELIDS	14	66		
CALANOID COPEPODS	395	1,866		
CYCLOPOID COPEPODS	22	104		
HARPACTICOID COPEPODS	6	28		
COPEPOD NAUPLII	54	255		
BARNACLE NAUPLII	11	52		
BARNACLE CYPRIS	16	76		
LARVACEANS (OIKOPLEURA)	6	28		
BRACHYURAN ZOEA	1	5		
	525	2,480		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA in 20/274 of sample	1	5		
CANCER MAGISTER	0	0		
CANCER spp.	0	0		

PLANKTON ANALYSIS

STATION 1 DATE April 14, 1971 COLLECTED BY G. Bailey LAB NO. 215

TOW TYPE 8 Meters TOW LENGTH 5 min ANALYZED BY R. Joslin

VOLUME SAMPLED (M^3) 1.75 CONCENTRATED VOLUME (ml) 312 ALIQUOT (ml) 30 PREDOMINANT ORGANISMS COPEPODS

NUMBER OF ORGANISMS/M^3 8677 NUMBER OF SPECIES 12 DIVERSITY INDEX 1.14

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ANNELIDS	29	172		
CALANOID COPEPODS	1,088	6,467		
CYCLOPOID COPEPODS	50	297		
HARPACTICOID COPEPODS	13	77		
COPEPOD NAUPLII	155	922		
COPEPOD JUVENILES	15	89		
BARNACLE NAUPLII	12	71		
BARNACLE CYPRIS	9	53		
ISOPODA	3	18		
EUPHAUSIDS	1	6		
MEDUSAE	2	12		
ECHINODERM LARVAE	4	24		
LARVACEANS (OIKOPLEURA)	79	469		
	1,460	8,677		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA in 70/312 of sample	1	3		
CANCER MAGISTER	0	0		
CANCER spp.	0	0		

PLANKTON ANALYSIS

ATION 2 DATE April 14, 1971 COLLECTED BY G. Bailey LAB NO. 255

W TYPE Surface TOW LENGTH 5 min ANALYZED BY E. Wilson

LUME MPLED (M^3) 3.15 CONCENTRATED VOLUME (ml) 240 ALIQUOT (ml) 30 PREDOMINANT ORGANISMS COPEPODS

MBER OF GANISMS/M^3 2550 NUMBER OF SPECIES 9 DIVERSITY INDEX 1.02

NTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ANNELIDS	15	38		
CALANOID COPEPODS	757	1,923		
CYCLOPOID COPEPODS	14	36		
COPEPOD NAUPLII	163	414		
BARNACLE NAUPLII	21	53		
EUPHAUSIDS	1	3		
LARVACEANS (OIKOPLEURA)	23	58		
DECAPOD ZOEA	2	5		
BRACHYURAN ZOEA	8	20		
	1,004	2,550		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA in 30/240 of sample	8	21		
CANCER MAGISTER	1	3		
CANCER spp.	6	15		
Other BRACHYURANS	1	2		

PLANKTON ANALYSIS

STATION 2 DATE April 14, 1971 COLLECTED BY G. Bailey LAB NO. 258

TOW TYPE Surface TOW LENGTH 5 min ANALYZED BY A. Mahood

VOLUME SAMPLED (M^3) 2.2 CONCENTRATED VOLUME (ml) 246 ALIQUOT (ml) 30 PREDOMINANT ORGANISMS COPEPODS

NUMBER OF ORGANISMS/M^3 2397 NUMBER OF SPECIES 10 DIVERSITY INDEX 1.16

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ANNELIDS	16	60		
CALANOID COPEPODS	417	1,554		
CYCLOPOID COPEPODS	1	4		
COPEPOD NAUPLII	137	511		
BARNACLE NAUPLII	35	130		
LARVACEANS (OIKOPLEURA)	27	101		
ECHINODERM LARVAE	1	4		
PELECYPOD LARVAE	4	15		
BRACHYURAN ZOEA	3	11		
Unknown DECAPOD ZOEA	2	7		
	643	2,397		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA in 30/246 of sample	3	11		
CANCER MAGISTER	0	0		
CANCER spp.	2	7		

PLANKTON ANALYSIS

ATION 2 DATE April 14, 1971 COLLECTED BY G. Bailey LAB NO. 250

W TYPE 8 Meters TOW LENGTH 5 min ANALYZED BY E. Wilson

OLUME AMPLED (M^3) 1.8 CONCENTRATED VOLUME (ml) 260 ALIQUOT (ml) 30 PREDOMINANT ORGANISMS COPEPODS

UMBER OF RGANISMS/M^3 3386 NUMBER OF SPECIES 10 DIVERSITY INDEX 1.11

ENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ANNELIDS	55	265		
CALANOID COPEPODS	470	2,264		
CYCLOPOID COPEPODS	21	101		
HARPACTICOID COPEPODS	1	5		
COPEPOD NAUPLII	66	318		
BARNACLE NAUPLII	63	303		
BARNACLE CYPRIS	8	39		
CUMACEANS	1	5		
LARVACEANS (OIKOPLEURA)	14	67		
BRACHYURAN ZOEA	4	19		
	703	3,386		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA in 30/260 of sample	4	19		
CANCER MAGISTER	0	0		
CANCER spp.	4	19		

PLANKTON ANALYSIS

STATION 2 DATE April 14, 1971 COLLECTED BY G. Bailey LAB NO. 254

TOW TYPE 8 Meters TOW LENGTH 5 min ANALYZED BY A. Mahood

VOLUME SAMPLED (M^3) 2.55 CONCENTRATED VOLUME (ml) 243 ALIQUOT (ml) 30 PREDOMINANT ORGANISMS COPEPODS

NUMBER OF ORGANISMS/M^3 2640 NUMBER OF SPECIES 11 DIVERSITY INDEX 1.27

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ANNELIDS	61	194		
CALANOID COPEPODS	556	1,767		
CYCLOPOID COPEPODS	18	57		
HARPACTICOID COPEPODS	1	3		
COPEPOD NAUPLII	116	368		
BARNACLE NAUPLII	49	156		
BARNACLE CYPRIS	4	13		
CHAETOGNATHS	1	3		
LARVACEANS (OIKOPLEURA)	18	57		
PELECYPOD LARVAE	6	19		
BRACHYURAN ZOEA	1	3		
	831	2,640		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA in 70/243 of sample	1	1		
CANCER MAGISTER	0	0		
CANCER spp.	1	1		

PLANKTON ANALYSIS

ATION 3 DATE April 14, 1971 COLLECTED BY G. Bailey LAB NO. 248

W TYPE Surface TOW LENGTH 5 min ANALYZED BY A. Mahood

OLUME AMPLED (M^3) 2.65 CONCENTRATED VOLUME (ml) 250 . ALIQUOT (ml) 30 PREDOMINANT ORGANISMS COPEPODS

UMBER OF RGANISMS/M^3 3645 NUMBER OF SPECIES 10 DIVERSITY INDEX 1.10

ENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ANNELIDS	18	57		
CALANOID COPEPODS	1,010	3,175		
CYCLOPOID COPEPODS	27	85		
HARPACTICOID COPEPODS	5	16		
COPEPOD NAUPLII	68	214		
BARNACLE NAUPLII	4	13		
EUPHAUSIDS	5	16		
LARVACEANS (OIKOPLEURA)	14	44		
GASTROPOD LARVAE	5	16		
BRACHYURAN ZOEA	3	9		
	1,159	3,645		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA in 30/250 of sample	3	9		
CANCER MAGISTER	0	0		
CANCER spp.	3	9		

PLANKTON ANALYSIS

STATION 3 DATE April 14, 1971 COLLECTED BY G. Bailey LAB NO. 246

TOW TYPE Surface TOW LENGTH 5 min ANALYZED BY E. Wilson

VOLUME SAMPLED (M^3) 5.15 CONCENTRATED VOLUME (ml) 214 ALIQUOT (ml) 30 PREDOMINANT ORGANISMS COPEPODS

NUMBER OF ORGANISMS/M^3 611 NUMBER OF SPECIES 8 DIVERSITY INDEX 1.09

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
CALANOID COPEPODS	395	546		
CYCLOPOID COPEPODS	7	10		
COPEPOD NAUPLII	17	24		
BARNACLE NAUPLII	7	10		
BARNACLE LARVAE	2	3		
LARVACEANS (OIKOPLEURA)	5	7		
BRACHYURAN ZOEA	3	4		
DECAPOD ZOEA	5	7		
	441	611		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA in 30/214 of sample	3	4		
CANCER MAGISTER	0	0		
CANCER spp.	3	4		

PLANKTON ANALYSIS

TION 3 DATE April 14, 1971 COLLECTED BY G. Bailey LAB NO. 245

V TYPE 8 Meters TOW LENGTH 5 min ANALYZED BY E. Wilson

LUME MPLED (M^3) 2.1 CONCENTRATED VOLUME (ml) 234 ALIQUOT (ml) 30 PREDOMINANT ORGANISMS COPEPODS

MBER OF GANISMS/M^3 3173 NUMBER OF SPECIES 9 DIVERSITY INDEX 0.74

NTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ANNELIDS	31	115		
CALANOID COPEPODS	326	1,211		
CYCLOPOID COPEPODS	71	264		
COPEPOD NAUPLII	235	873		
BARNACLE NAUPLII	77	286		
BARNACLE CYPRIS	5	19		
EUPHAUSIDS	1	4		
LARVACEANS (OIKOPLEURA)	107	397		
BRACHYURAN ZOEA	1	4		
	854	3,173		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA in 30/234 of sample	1	4		
CANCER MAGISTER	0	0		
CANCER spp.	0	0		

PLANKTON ANALYSIS

STATION 3 DATE April 14, 1971 COLLECTED BY G. Bailey LAB NO. 256

TOW TYPE 8 Meters TOW LENGTH 5 min ANALYZED BY R. Joslin

VOLUME SAMPLED (M^3) 2.2 CONCENTRATED VOLUME (ml) 360 ALIQUOT (ml) 30 PREDOMINANT ORGANISMS COPEPODS

NUMBER OF ORGANISMS/M^3 4286 NUMBER OF SPECIES 12 DIVERSITY INDEX 1.32

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ANNELIDS	21	116		
CALANOID COPEPODS	287	1,587		
CYCLOPOID COPEPODS	109	603		
HARPACTICOID COPEPODS	8	44		
COPEPOD NAUPLII	297	1,642		
BARNACLE NAUPLII	12	66		
ISOPODA	1	6		
EUPHAUSIDS	2	11		
CHAETOGNATHS	3	17		
LARVACEANS (OIKOPLEURA)	31	171		
GASTROPOD LARVAE	3	17		
BRACHYURAN ZOEA	1	6		
	775	4,286		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA in 30/360 of sample	1	6		
CANCER MAGISTER	0	0		
CANCER spp.	0	0		

PLANKTON ANALYSIS

ATION 4 DATE April 14, 1971 COLLECTED BY G. Bailey LAB NO. 252

W TYPE Surface TOW LENGTH 5 min ANALYZED BY R. Joslin

LUME MPLED (M^3) 3.05 CONCENTRATED VOLUME (ml) 220 ALIQUOT (ml) 30 PREDOMINANT ORGANISMS COPEPODS

MBER OF GANISMS/M^3 1296 NUMBER OF SPECIES 11 DIVERSITY INDEX 1.40

NTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ANNELIDS	16	38		
CALANOID COPEPODS	333	801		
CYCLOPOID COPEPODS	6	14		
HARPACTICOID COPEPODS	1	2		
COPEPOD NAUPLII	102	246		
BARNACLE NAUPLII	9	22		
BARNACLE CYPRIS	9	22		
CHAETOGNATHS	1	2		
LARVACEANS (OIKOPLEURA)	56	135		
GASTROPOD LARVAE	3	7		
BRACHYURAN ZOEA	3	7		
	539	1,296		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA				
in 30/220 of sample	3	7		
CANCER MAGISTER	0	0		
CANCER spp.	0	0		

PLANKTON ANALYSIS

STATION 4 DATE April 14, 1971 COLLECTED BY G. Bailey LAB NO. 253

TOW TYPE Surface TOW LENGTH 5 min ANALYZED BY A. Mahood

VOLUME SAMPLED (M^3) 2.25 CONCENTRATED VOLUME (ml) 270 ALIQUOT (ml) 30 PREDOMINANT ORGANISMS COPEPODS

NUMBER OF ORGANISMS/M^3 2524 NUMBER OF SPECIES 8 DIVERSITY INDEX 0.89

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ANNELIDS	27	108		
CALANOID COPEPODS	366	1,464		
CYCLOPOID COPEPODS	8	32		
COPEPOD NAUPLII	194	776		
BARNACLE CYPRIS	1	4		
LARVACEANS (OIKOPLEURA)	31	124		
ECHINODERM LARVAE	1	4		
BRACHYURAN ZOEA	3	12		
	631	2,524		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA in 30/270 of sample	3	12		
CANCER MAGISTER	0	0		
CANCER spp.	0	0		

PLANKTON ANALYSIS

ATION 4 DATE April 14, 1971 COLLECTED BY G. Bailey LAB NO. 251

OW TYPE 8 Meters TOW LENGTH 5 min ANALYZED BY A. Mahood

OLUME AMPLED (M^3) 1.9 CONCENTRATED VOLUME (ml) 262 ALIQUOT (ml) 30 PREDOMINANT ORGANISMS COPEPODS

UMBER OF RGANISMS/M^3 1998 NUMBER OF SPECIES 9 DIVERSITY INDEX 1.05

ENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ANNELIDS	30	138		
CALANOID COPEPODS	210	965		
CYCLOPOID COPEPODS	45	207		
COPEPOD NAUPLII	96	441		
BARNACLE NAUPLII	39	179		
BARNACLE CYPRIS	2	9		
LARVACEANS (OIKOPLEURA)	9	41		
PELECYPOD LARVAE	3	14		
BRACHYURAN ZOEA	1	5		
	435	1,999		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA in 30/262 of sample	1	5		
CANCER MAGISTER	0	0		
CANCER spp.	0	0		

PLANKTON ANALYSIS

STATION 4 DATE April 14, 1971 COLLECTED BY G. Bailey LAB NO. 257

TOW TYPE 8 Meters TOW LENGTH 5 min ANALYZED BY A. Mahood

VOLUME SAMPLED (M^3) 3.65 CONCENTRATED VOLUME (ml) 220 ALIQUOT (ml) 30 PREDOMINANT ORGANISMS COPEPODS

NUMBER OF ORGANISMS/M^3 1659 NUMBER OF SPECIES 11 DIVERSITY INDEX 1.35

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ANNELIDS	58	117		
CALANOID COPEPODS	477	958		
CYCLOPOID COPEPODS	43	86		
HARPACTICOID COPEPODS	15	30		
COPEPOD NAUPLII	131	263		
BARNACLE NAUPLII	63	127		
BARNACLE CYPRIS	15	30		
EUPHAUSIDS	1	2		
LARVACEANS (OIKOPLEURA)	19	38		
PELECYPOD LARVAE	2	4		
BRACHYURAN ZOEA	2	4		
	826	1,659		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA in 30/220 as sample	2	4		
CANCER MAGISTER	0	0		
CANCER spp.	0	0		

PLANKTON ANALYSIS

ATION 5 DATE April 14, 1971 COLLECTED BY G. Bailey LAB NO. 224

W TYPE Surface TOW LENGTH 5 min ANALYZED BY R. Joslin

OLUME AMPLED (M^3) 2.7 CONCENTRATED VOLUME (ml) 276 ALIQUOT (ml) 30 PREDOMINANT ORGANISMS COPEPODS

UMBER OF RGANISMS/M^3 1619 NUMBER OF SPECIES 12 DIVERSITY INDEX 1.49

ENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ANNELIDS	5	17		
CALANOID COPEPODS	235	801		
CYCLOPOID COPEPODS	11	37		
HARPACTICOID COPEPODS	4	14		
COPEPOD NAUPLII	120	409		
CLADOCERANS	1	3		
BARNACLE NAUPLII	29	99		
BARNACLE CYPRIS	2	7		
EUPHAUSIDS	3	10		
LARVACEANS (OIKOPLEURA)	60	205		
ECHINODERM LARVAE	4	14		
BRACHYURAN ZOEA	1	3		
	475	1,619		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA in 30/276 of sample	1	3		
CANCER MAGISTER	0	0		
CANCER spp.	0	0		

PLANKTON ANALYSIS

STATION 5 DATE April 14, 1971 COLLECTED BY G. Bailey LAB NO. 226

TOW TYPE Surface TOW LENGTH 5 min ANALYZED BY A. Mahood

VOLUME SAMPLED (M^3) 3.25 CONCENTRATED VOLUME (ml) 250 ALIQUOT (ml) 30 PREDOMINANT ORGANISMS COPEPODS

NUMBER OF ORGANISMS/M^3 2756 NUMBER OF SPECIES 10 DIVERSITY INDEX 1.28

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ANNELIDS	14	36		
CALANOID COPEPODS	628	1,609		
CYCLOPOID COPEPODS	14	36		
HARPACTICOID COPEPODS	3	8		
COPEPOD NAUPLII	264	676		
BARNACLE NAUPLII	33	85		
BARNACLE CYPRIS	1	3		
EUPHAUSIDS	3	8		
LARVACEANS (OIKOPLEURA)	110	282		
BRACHYURAN ZOEA	5	13		
	1,075	2,756		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA in 30/250 of sample	5	13		
CANCER MAGISTER	0	0		
CANCER spp.	0	0		

PLANKTON ANALYSIS

ATION 5 DATE April 14, 1971 COLLECTED BY G. Bailey LAB NO. 218

W TYPE 8 Meters TOW LENGTH 5 min ANALYZED BY A. Mahood

LUME MPLED (M^3) 4.4 CONCENTRATED VOLUME (ml) 238 ALIQUOT (ml) 26 PREDOMINANT ORGANISMS COPEPODS

MBER OF GANISMS/M^3 2457 NUMBER OF SPECIES 9 DIVERSITY INDEX 1.02

NTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ANNELIDS	21	44		
CALANOID COPEPODS	885	1,842		
CYCLOPOID COPEPODS	43	89		
HARPACTICOID COPEPODS	6	12		
COPEPOD NAUPLII	186	388		
BARNACLE NAUPLII	5	10		
BARNACLE CYPRIS	4	8		
LARVACEANS (OIKOPLEURA)	30	62		
BRACHYURAN ZOEA	1	2		
	1,181	2,457		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA in 26/238 of sample	1	2		
CANCER MAGISTER	0	0		
CANCER spp.	0	0		

PLANKTON ANALYSIS

STATION 5 DATE April 14, 1971 COLLECTED BY G. Bailey LAB NO. 222

TOW TYPE 8 Meters TOW LENGTH 5 min ANALYZED BY R. Joslin

VOLUME SAMPLED (M^3) 1.7 CONCENTRATED VOLUME (ml) 264 ALIQUOT (ml) 25 PREDOMINANT ORGANISMS COPEPODS

NUMBER OF ORGANISMS/M^3 3212 NUMBER OF SPECIES 12 DIVERSITY INDEX 1.37

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ANNELIDS	18	112		
CALANOID COPEPODS	324	2,013		
CYCLOPOID COPEPODS	14	87		
HARPACTICOID COPEPODS	9	56		
COPEPOD NAUPLII	89	553		
BARNACLE NAUPLII	12	75		
BARNACLE CYPRIS	11	68		
ISOPODA	1	6		
EUPHAUSIDS	1	6		
LARVACEANS (OIKOPLEURA)	35	217		
BRACHYURAN ZOEA	3	19		
	517	3,212		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA				
in 25/264 of sample	3	19		
CANCER MAGISTER	0	0		
CANCER spp.	3	19		

PLANKTON ANALYSIS

ATION 6 DATE April 14, 1971 COLLECTED BY G. Bailey LAB NO. 220

OW TYPE Surface TOW LENGTH 5 min ANALYZED BY A. Mahood

OLUME AMPLED (M^3) 2.5 CONCENTRATED VOLUME (ml) 320 ALIQUOT (ml) 30 PREDOMINANT ORGANISMS COPEPODS

UMBER OF RGANISMS/M^3 3210 NUMBER OF SPECIES 12 DIVERSITY INDEX 1.36

ENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ANNELIDS	2	9		
CALANOID COPEPODS	295	1,260		
CYCLOPOID COPEPODS	39	166		
HARPACTICOID COPEPODS	1	4		
COPEPOD NAUPLII	305	1,302		
BARNACLE NAUPLII	4	17		
BARNACLE CYPRIS	1	4		
AMPHIPOD	1	4		
CLADOCERAN	1	4		
LARVACEANS (OIKOPLEURA)	98	419		
ECHINODERM LARVAE	1	4		
BRACHYURAN ZOEA	4	17		
	752	3,210		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA in 30/320 of sample	4	17		
CANCER MAGISTER	0	0		
CANCER spp.	0	0		

PLANKTON ANALYSIS

STATION 6 DATE April 14, 1971 COLLECTED BY G. Bailey LAB NO. 216

TOW TYPE Surface TOW LENGTH 5 min ANALYZED BY A. Mahood

VOLUME SAMPLED (M^3) 1.7 CONCENTRATED VOLUME (ml) 300 ALIQUOT (ml) 30 PREDOMINANT ORGANISMS COPEPODS

NUMBER OF ORGANISMS/M^3 1929 NUMBER OF SPECIES 9 DIVERSITY INDEX 1.19

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ANNELIDS	5	29		
CALANOID COPEPODS	111	654		
CYCLOPOID COPEPODS	12	71		
COPEPOD NAUPLII	94	553		
BARNACLE NAUPLII	4	24		
BARNACLE CYPRIS	2	12		
LARVACEANS (OIKOPLEURA)	74	435		
ECHINODERM LARVAE	2	12		
GASTROPOD LARVAE	24	141		
	328	1,929		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA in 30/300 of sample	0	0		
CANCER MAGISTER	0	0		
CANCER spp.	0	0		

PLANKTON ANALYSIS

TATION 6 DATE April 14, 1971 COLLECTED BY G. Bailey LAB NO. 227

OW TYPE 8 Meters TOW LENGTH 5 min ANALYZED BY A. Mahood

OLUME AMPLED (M^3) 3.75 CONCENTRATED VOLUME (ml) 410 ALIQUOT (ml) 40 PREDOMINANT ORGANISMS COPEPODS

UMBER OF RGANISMS/M^3 2271 NUMBER OF SPECIES 9 DIVERSITY INDEX 1.04

ENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ANNELIDS	25	68		
CALANOID COPEPODS	203	555		
CYCLOPOID COPEPODS	192	525		
HARPACTICOID COPEPODS	5	14		
COPEPOD NAUPLII	233	636		
BARNACLE NAUPLII	3	8		
BARANCLE CYPRIS	8	22		
LARVACEANS (OIKOPLEURA)	140	383		
BRACHYURAN ZOEA	22	60		
	831	2,271		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA in 90/410 of sample	57	69		
CANCER MAGISTER	0	0		
CANCER spp.	1	1		

PLANKTON ANALYSIS

STATION 6 DATE April 14, 1971 COLLECTED BY G. Bailey LAB NO. 217

TOW TYPE 8 Meters TOW LENGTH 5 min ANALYZED BY A. Mahood

VOLUME SAMPLED (M^3) 1.6 CONCENTRATED VOLUME (ml) 360 ALIQUOT (ml) 40 PREDOMINANT ORGANISMS COPEPODS

NUMBER OF ORGANISMS/M^3 10,367 NUMBER OF SPECIES 14 DIVERSITY INDEX 1.41

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
ANNELIDS	57	321		
CALANOID COPEPODS	591	3,324		
CYCLOPOID COPEPODS	87	489		
HARPACTICOID COPEPODS	8	45		
COPEPOD NAUPLII	905	5,091		
BARNACLE NAUPLII	2	11		
BARNACLE CYPRIS	5	28		
EUPHAUSIDS	9	51		
CHAETOGNATHS	2	11		
LARVACEANS (OIKOPLEURA)	137	771		
ECHINODERM LARVAE	2	11		
PELECYPOD LARVAE	1	6		
BRACHYURAN ZOEA	37	208		
	1,843	10,367		
CRAB ALIQUOT				
Total BRACHYURAN ZOEA in 70/360 of sample	89	250		
CANCER MAGISTER	0	0		
CANCER spp.	1	3		

APPENDIX B

ACUTE TOXICITY BIOASSAY DATA

Acute Toxicity Bioassay Experiment - 1

Test Organism: Cancer magister, First-day zoea

Type of Bioassay: Static Starting Date: April 3, 1971

RATIO OF EFFLUENT: WATER	REPLICATE	SURVIVORS AT TIME INDICATED (DAYS)									NOTES
		0	1	2	3	4	5				
Control	A	10	10	10	10	10	5				Temperature range was 11.0 to 11.5 C for this experiment.
	B	10	10	10	10	8	2				
	C	10	10	10	9	9	7				
1:200	A	10	10	10	8	6	6				Seawater used was cloudy, detritis built up on the bottom of each bowl.
	B	10	10	9	9	8	8				
	C	10	10	9	9	9	8				
1:100	A	10	10	10	10	7	6				Zoea fed newly hatched brine shrimp nauplii.
	B	10	10	10	10	10	10				
	C	10	9	9	9	8	7				
1:50	A	10	9	9	9	9	8				
	B	10	10	9	9	5	4				
	C	10	10	9	8	6	3				
1:20	A	10	10	9	9	7	5				
	B	10	10	10	10	10	7				
	C	10	10	10	9	5	3				

Test Organism: Cancer magister, First-day zoea hatched in 1:20 sewage[a]

Type of Bioassay: Static Starting Date: April 9, 1971

RATIO OF EFFLUENT: WATER	REPLICATE	SURVIVORS AT TIME INDICATED (DAYS)									NOTES
		0	1	2	3	4					
Control	A	10	10	9	5	5					
	B	10	10	10	10	9					
	C	10	10	9	8	8					
1:200	A	10	9	9	9	9					Water bath temperatures recorded in laboratory; initially 12.0 C; 24 hours 11.5 C; 48 hours 11.0 C; 72 hours 12.8 C
	B	10	10	10	9	9					
	C	10	8	7	7	7					
1:100	A	10	10	10	9	8					[a] Eggs were subjected to 24 hours in the effluent dilution before hatching. They hatched in the effluent and viable zoea were removed to the static tests.
	B	10	10	10	7	5					
	C	10	10	9	8	8					
1:50	A	10	10	10	9	9					
	B	10	10	9	9	8					
	C	10	10	10	8	8					
1:20	A	10	10	10	8	8					
	B	10	10	9	9	7					
	C	10	10	9	9	9					

Test Organism: Cancer magister, Zoea hatched 9, 1971[a]

Type of Bioassay: Static

Starting Date: April 12, 1971

RATIO OF EFFLUENT: WATER	REPLICATE	SURVIVORS AT TIME INDICATED (DAYS)									NOTES
		0	1	2	3	4					
Control	A 3-day	10	10	8	5	5					Temperature range was from 11.0 C to 13.5 C during these experiments.
1:200	zoea	10	9	7	5	4[b]					
1:100		10	9	6	6	5					
1:50		10	10	10	8	6					
1:20		10	9	9	7	7					
	B	10	10	9	8	7					
1:200		10	9	6	5	5[b]					
1:100		10	10	9	7[b]	5					
1:50		10	10	9	8	8[b]					
1:20		10	9	7	7[b]	0[b]					
	C	10	9	8	5	2[b]					
1:200		10	10	10	6	6					a Experiments were set up on consecutive days with zoea from the same hatch.
1:100		10	10	10	10	7					
1:50		10	10	10	10	10					
1:20		10	10	10	9	8					b Exuviae found in static bowls during inspection - indicates molting of zoea to second instars.
	D	10	8[b]	4	0	0					
1:200		10	8	2	0	0					
1:100		10	7	5[b]	1	0					c Zoea lethargic when introduced int this static experiment.
1:50		10	8	5	1	0					
1:20		10	6	4[b]	2	1					
	E	10	5	2	2	0					
1:20		10	6	2	1	1					
1:100		10	8	4[b]	3	1					
1:50		10	5	3	2[b]	1					
1:20		10	9[b]	6	2	0					

Acute Toxicity Bioassay Experiment - 4

Test Organism: *Cancer magister*, First day zoea hatched in 1:200 dilution[a]

Type of Bioassay: Static

Starting Date: April 13, 1971

RATIO OF EFFLUENT: WATER	REPLICATE	SURVIVORS AT TIME INDICATED (DAYS)									NOTES
		0	1	2	3	4					
Control	A	10	10	10	10	10					Temperature ranged from 11.5 C to 12.5 C during this experiment
	B	10	10	9	8	8					
	C	10	10	9	9	9					a These eggs were exposed (in vivo to a 1:200 dilution of effluent for 96 hours April 8 to April 11 and kept in sea water until hatched out on April 12.
1:200	A	10	9	9	8	8					
	B	10	10	10	7	5					
	C	10	10	9	9	9					
1:100	A	10	9	9	9	8					
	B	10	10	9	8	8					
	C	10	9	9	9	9					
1:50	A	10	10	9	7	4					
	B	10	9	8	8	8					
	C	10	10	10	9	9					
1:20	A	10	10	9	9	6					
	B	10	10	9	9	8					
	C	10	10	10	9	6					

Acute Toxicity Bioassay Experiment - 5

Test Organism: *Cancer magister*, First-day zoea

Type of Bioassay: Static

Starting Date: April 15, 1971

RATIO OF EFFLUENT: WATER	REPLICATE	SURVIVORS AT TIME INDICATED (DAYS)									NOTES
		0	1	2	3	4					
Control	A	10	10	10	8	8					Temperature ranged from 11.0 C to 12.5 C during this experiment.
	B	10	9	9	8	8					
1:200	A	10	10	10	10	9					
	B	10	10	10	10	7					
1:100	A	10	10	10	10	9					
	B	10	10	10	10	9					
1:50	A	10	10	10	9	8					
	B	10	9	8	8	8					
1:20	A	10	10	10	10	10					
	B	10	10	10	10	9					

Acute Toxicity Bioassay Experiment - 6

Test Organism: Cancer magister, First-day zoea hatched in 1:100 dilution.

Type of Bioassay: Static Starting Date: April 18, 1971

RATIO OF EFFLUENT: WATER	REPLICATE	SURVIVORS AT TIME INDICATED (DAYS)									NOTES
		0	1	2	3	4					
Control	A	10	8	5	5	5					Temperature ranged from 10.5 C to 12.5 C during this experiment.
	B	10	10	8	8	8					
1:200	A	10	10	9	9	9					
	B	10	10	9	8	7					
1:100	A	10	10	9	9	9					
	B	10	9	8	8	8					
1:50	A	10	9	8	7	6					a These eggs were exposed (in vivo) to a 1:100 dilution of effluent for 96 hours April 8 to April 11 and kept in sea water until hatched out on April 18.
	B	10	10	10	7	5					
1:20	A	10	9	7	7	7					
	B	10	8	8	7	7					

Acute Toxicity Bioassay Experiment - 7

Test Organism: Cancer magister, Fifth-day zoea

Type of Bioassay: Static

Starting Date: April 19, 1971

RATIO OF EFFLUENT: WATER	REPLICATE	SURVIVORS AT TIME INDICATED (DAYS)									NOTES
		0	1	2	3	4					
Control	A	10	10	8	7	6					Temperature range during this experiment was 10.5 C to 11.0 C.
	B	10	10	8	8	6					
	C	10	10	10	10	8					
1:200	A	10	9	8	7	5					
	B	10	10	8	7	6					
	C	10	10	10	9	8					
1:100	A	10	9	9	9	8					
	B	10	10	9	7	6					
	C	10	10	10	8	5					
1:50	A	10	10	9	6	6					
	B	10	9	8	8	5					
	C	10	10	8	7	6					
1:20	A	10	8	6	4	4					
	B	10	9	5	4	3					
	C	10	10	8	7	7					

Test Organism: Pagurus samuelis, Adult crabs

Type of Bioassay: Continuous-flow Starting Date: May 21, 1971

RATIO OF EFFLUENT: WATER	REPLICATE	SURVIVORS AT TIME INDICATED (DAYS)									NOTES
		0	1	2	3	4					
Control		10		10		10					pH was 6.9 to 7.0 in all tanks.
1:400		10		10		10					The crabs were released to roam at large in the diluted tanks.
1:200		10		10		10					The crabs were collected in Horseshoe Cove, Sonoma County.
1:100		10		10		10					Sea water flow restricted during a portion of the experiment. 1:100 and 1:50 dilutions are probably more concentrated after the 3rd day, precise dilutions ar unknown.
1:50		10		10		10					The animals were fed minced clams at each count.

Acute Toxicity Bioassay Experiment - 9

Test Organism: *Petrolisthes cinctipes*, adult crabs

Type of Bioassay: Continuous-flow Starting Date: May 25, 1971

RATIO OF EFFLUENT: WATER	REPLICATE	SURVIVORS AT TIME INDICATED (DAYS)									NOTES
		0	1	2	3	4					
Control		10				9					Crabs were set free in the dilution tanks and a well washed large stone was placed in each tank. The crabs stayed under the stones.
1:400		10				9					
1:200		10				10					
1:100		10				9					The crabs were fed minced clams every two days.
1:50		10				10					
1:20		10				10					

Test Organism: Pagurus samuelis, adult crabs

Type of Bioassay: Continuous-flow Starting Date: May 25, 1971

RATIO OF EFFLUENT: WATER	REPLICATE	SURVIVORS AT TIME INDICATED (DAYS)									NOTES
		0	1	2	3	4					
Control		10				10					Adult crabs were left to roam at large in the dilution aquaria.
1:400		10				10					
1:200		10				8					The crabs were fed minced clams every two days.
1:100		10				9					
1:50		10				10					

Acute Toxicity Bioassay Experiment - 11

Test Organism: Cancer magister, Megalopa - juvenile crabs

Type of Bioassay: Continuous-flow Starting Date: May 25, 1971

RATIO OF EFFLUENT: WATER	REPLICATE	SURVIVORS AT TIME INDICATED (DAYS)									NOTES
		0	2	4	15	19	23	31	35	50	
Control		9[a]	1[a] 7[b]	8[b]	8[b]	7[b]	7[b]	5[b]	5[b]	5[b]	Megolopa were collected in plankton net, off Bodega head on May 23, 1971.
1:100		9[a]	3[a] 6[b]	9[b]	9[b]	6[b]	6[b]	6[b]	6[b]	6[b]	The juvenile crabs were fed minced clam meat periodically.
1:50		9[a]	4[a] 5[b]	9[b]	9[b]	8[b]	7[b]	7[b]	7[b]	6[b]	Juvenile crabs ranged from 4 to 9 mm on day 7.

MEASUREMENTS OF JUVENILE CRABS ON DAY 50 IN MILLIMETERS[c]

CONTROL	1:100	1:50
13	11	11
11	11	10
12	12	9
12	10	10
11	10	10
	10	9

The crabs were keyed out on about the 40th day as Cancer magister.

[a] Megalopa

[b] Juvenile crabs

[c] Measurements were taken across carapace width at widest area.

Test Organism: Petrolisthes cinctipes, first-day zoea

Type of Bioassay: Continuous-flow zoea chambers Starting Date: May 26, 1971

RATIO OF EFFLUENT: WATER	REPLICATE	SURVIVORS AT TIME INDICATED (DAYS)									NOTES
		0	1	2	3	4					
Control		10				8					Zoea hatched in laboratory from female crabs collected at Doran Strip, Bodega Bay, Sonoma County.
1:400		10				7					
1:200		10				9					
1:100		10				8					
1:50		10				8					

st Organism: Petrolisthes cinctipes eggs (in vivo)[a]

pe of Bioassay: Continuous-flow zoea chambers **Starting Date:** May 25, 1971

RATIO OF EFFLUENT: WATER	REPLICATE	RATIO OF ZOEA : PREZOEA : NONVIABLE EGGS OBSERVED AT DATE INDICATED											
		6/6	6/7	6/8	6/9	6/10	6/11	6/12	6/13	6/14	6/15	6/16	
ntrol	A	48/6/5	49/6/11	c									
	B		1	13	17/0/1	18/0/1			19/0/1	37/0/1	55/0/1	66/0/1	
400	A					50 eggs left (appeared viable)							
100	A					50 eggs left (appeared viable)							
50	A		64/1	64/2/1	c								
	B		9		9/1		9/1/4	c					
	C		1/1	1/2	2/2/1	2/2	c						
20	A		1/0/1		2/1/1	d		2/1/2					
	B					50 eggs left (some appeared viable)							

riginal number of eggs as estimated from an observation of the egg masses and a ubjective calculation of the number of eggs contained in these masses.

otal numbers are cumulative up to each date indicated; no eggs hatched out after 6/16. oea, prezoea eggs determined not viable (cloudy & decomposed) were removed at each ount and stored for observation.

o eggs left on the female crabs at this observation; the crabs were removed from the xperiment.

ive eggs were left in the egg mass at this count and they appeared viable.

Test Organism: Pugettia producta, 2nd-day zoea

Type of Bioassay: Continuous-flow zoea chambers Starting Date: June 10, 1971

RATIO OF EFFLUENT: WATER	REPLICATE	SURVIVORS AT TIME INDICATED (DAYS)									NOTES
		0	1	2	3	4					
Control											
	A	10				10					Pugettia collected at Doran Strip, Bodega harbor, Sonoma Co. hatched in laboratory.
	B	10				10					
	C	10				Ø					
1:200											
	A	10				3					
	B	10				9					
	C	10				1					
1:50											
	A	10				Ø					
	B	10				10					
	C	10				5					

est Organism: Pugettia producta, 7th-day zoea

ype of Bioassay: Continuous-flow zoea chambers **Starting Date:** June 15, 1971

ATIO OF FFLUENT: WATER	REPLI-CATE	SURVIVORS AT TIME INDICATED (DAYS)									NOTES
		0	4	8	12						
ontrol											Pugettia collected on jetty at entrance to Bodega harbor, Sonoma County.
	A	10	4	2	ø						
	B	10	ø								Zoea were hatched in laboratory.
	C	10	8	3	ø						Zoea were fed brine shrimp nauplii.
:200											
	A	10	7	5	ø						
	B	10	7	6	ø						
	C	10	7	6	ø						
:100											
	A	10	9	8	ø						
	B	10	7	5	ø						
	C	10	6	5	ø						
:50											
	A	10	ø								
	B	10	5	ø							
	C	10	1	1	ø						

Acute Toxicity Bioassay Experiment - 16

Test Organism: *Pugettia producta*, 1st day zoea

Type of Bioassay: Continuous-flow zoea chambers Starting Date: June 28, 1971

RATIO OF EFFLUENT: WATER	REPLICATE	SURVIVORS AT TIME INDICATED (DAYS) 0	4	8							NOTES
Control	A	15	15	13							Oviperous female crab was collected on Bodega harbor jetty and zoea were hatched in laboratory.
	B	15	13	13							
1:400											
	A	15	13	1							Heavy algal and fungal growth in 1:400 A, 1:200 A and 1:100 A noted on 8th day.
	B	15	14	13							
1:200											Zoea were fed brine shrimp nauplii.
	A	15	10	3							
	B	15	15	12							
1:100											
	A	15	14	2							
	B	15	12	9							
1:50											
	A	15	14	0							
	B	15	15	0							

Acute Toxicity Bioassay Experiment - 17

Test Organism: Pugettia producta, 6th day zoea

Type of Bioassay: Continuous-flow zoea chambers Starting Date: July 2, 1971

RATIO OF EFFLUENT: WATER	REPLICATE	SURVIVORS AT TIME INDICATED (DAYS)									NOTES
		0	1	2	3	4					
Control											Pugettia crab collected on Doran strip, Sonoma County, and zoea were hatched in laboratory.
		15				14					
1:400		15				13					
1:200		15				7					Zoea were fed brine shrimp nauplii.
1:100		15				11					
1:50		15				9					

Test Organism: *Cancer magister* eggs (*in vitro*)

Type of Bioassay: Continuous-flow egg chambers **Starting Date:** August 20, 1973

RATIO OF EFFLUENT: WATER	REPLICATE[b]	RATIO OF ZOEA : PREZOEA SURVIVING AT DATE INDICATED[a]												
		8/23	8/24	8/25	8/26	8/27	8/28							
Control	A	12/37		34/89	34/96		34/96							
	B	38/61		43/83	43/92		43/93							
	C	17/37		17/62	17/72		17/76							
1:200	A	13/49		18/77	18/89		18/90							
	B	30/108		37/122	37/132		37/133							
	C	17/75		17/78	17/86		17/86							
1:100	A	27/71		27/109	27/116		27/118							
	B	19/91		22/103	22/114		22/115							
	C	17/75		18/76	18/92		18/92							
1:50	A	22/86		22/143	22/149		22/153							
	B	29/77		34/80	34/85		34/85							
	C	8/65		8/71	8/76		8/76							

[a]The counts of hatches are cumulative. The zoea and prezoea from each count were removed to separate containers and observed periodically.

[b]The A, B, and C series eggs were removed from the female crab and placed in the experiment on August 20, 21, and 22, 1971, respectively.

Test Organism: Cancer magister, 1st day zoea

Type of Bioassay: Continuous-flow zoea chambers Starting Date: August 24, 1971

RATIO OF EFFLUENT: WATER	REPLICATE	SURVIVORS AT TIME INDICATED (DAYS)									NOTES
		1	2	3	4						
Control											
	A	10			6						Zoea were fed brine shrimp nauplii by pipette.
	B	10			7						
	C	10			6						
	D	10			5						
	E	10			8						
1:200											
	A	10			2						
	B	10			6						
	C	10			5						
	D	10			7						
	E	10			8						
1:100											
	A	10			5						
	B	10			2						
	C	10			3						
	D	10			1						
	E	10			5						
1:50											
	A	10			6						
	B	10			3						
	C	10			6						
	D	10			3						
	E	10			8						